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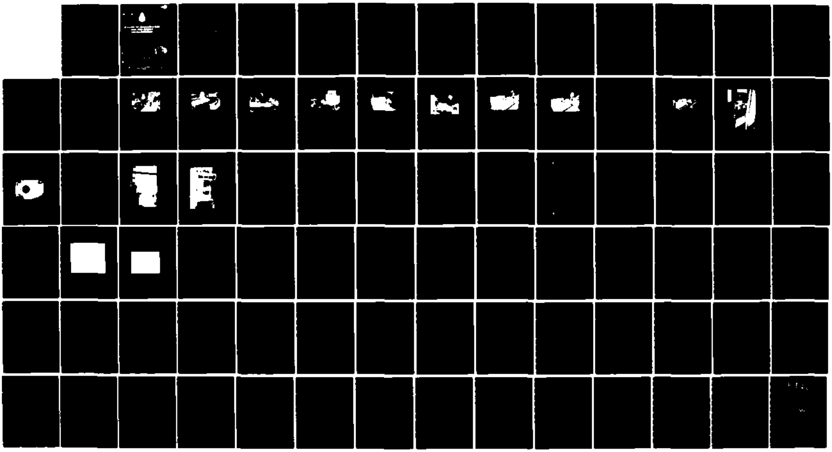

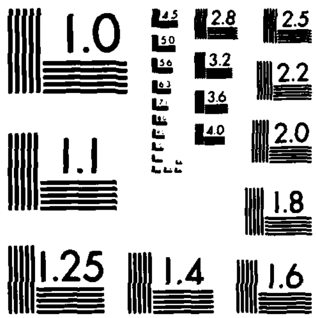

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INSTALLATION, TEST AND OPERATION OF SEASAT OPTICAL SIGNAL RECORDER AT SHOE COVE, NEWFOUNDLAND

by

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ABSTRACT

This report details the installation and operation of a precision Optical Signal Recording System for Synthetic Aperture Radar transmissions from SEASAT-A Satellite. The system was for the most part constructed under two contracts with Canadian and U.S. industries.

Uncorrelated imagery stored on high density, digital and analog tapes was transposed onto film as interferrograms for optical correlation at DREO.

The resulting imagery was acceptable as survey quality for archiving by NAPL.

The Remote Sensing Section of DREO coordinated the installation and testing of the Recorder at the Shoe Cove Satellite Receiving Station, Newfoundland. In March 1980 the recorder was removed from Shoe Cove for installation at DREO Ottawa.

RÉSUMÉ

Ce rapport contient le détail des procédures d'installation et d'opération de l'enregistreur optique de signaux pour les données de radar à antenne synthétique du satellite SEASAT-A. Cet appareil fut construit principalement grâce à deux contracts octroyés à l'industrie canadienne et américaine.

Les images non-corrélées emmagasinées sur des rubans magnétiques à haute densité et sur des rubans analogues ont été transférées sur film afin de produire des interférogrammes pour corrélation optique au CRDO.

L'imagerie résultante fut jugée conforme aux normes de traitement préliminaire et classée dans les archives de la Photothèque Nationale de l'Air.

La section de télédétection de CRDO a coordonné l'installation et les tests de l'enregistreur à la station de réception de sigaux satellite de Shoe Cove. L'enregisteur fut déménagé de Shoe Cove au CRDO à Ottawa en mars 1980.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

ACKNOWLEDGMENT

Credit and appreciation should be given the station staff at Shoe Cove Satellite Receiving Station for the invaluable support and good humour unselfishly supplied during this encounter.

Special mention for Rick Terry (NORDCO Ltd.) who worked long hours, assisting the authors and the project.

1.0 INTRODUCTION

This technical note reports on the installation and operation of the optical recorder constructed under two major contracts. The recorder system was then installed at the Shoe Cove Satellite Receiving Station, Newfoundland by DREO personnel. It recorded interferograms generated by the synthetic aperture radar (SAR) aboard the SEASAT-A Satellite.[1] (June to Oct 1978)

Originally it was intended that an optical recorder be installed at Shoe Cove to receive SAR data on a continuous basis, but due to the early demise of SEASAT-A, the optical recording instrumentation from the contractors was not received in time to make real time interferogram recordings. The DREO Back-up Optical Recorder[2] was however on line to record some thirty live passes at Shoe Cove and its operation is reported under Tech Note #79/14.

To aid in the understanding of the system, the basic concepts are noted here.

The data from the SAR was to be recorded in real time in two 50 km swaths (Range) across two high resolution CRT's. The CRT traces were recorded by transfer lenses onto film and the motion of the film created the azimuth information. The linearity of the CRT trace, the optics, the film drive and the resolution on the film are critical parameters.

The system described in this report only records a single 50 km (163 μs duration) range swath. This is one of two identical optical recorders manufactured under contract to DREO.

Other instrumentation at Shoe Cove recorded analog and digital versions of the interferograms during the period that real time transmissions were received. These recordings have been transposed onto film via the optical recorder for subsequent correlation on a new optical correlator at DREO. Other SAR data was recorded on digital tape at various U.S. Receiving Stations.

All film processing was made by Reproduction Centre, NAPL, Ottawa, and CFPU Rockcliffe Ottawa.

Appendices at the back of this Technical Note provide additional details on some of the aspects including an Operator's Guide (Appendix A).

1.1 Instrument Contracts

The contracts for two optical signal recorder lenses and two film drives was given to Canadian Instrumentation and Research Ltd. (CIR) in Toronto.[3]

The film drive electronic control consul and one of two of the optical film drive recorders, was received at DREO December 1978; it was assembled and operated in a satisfactory manner by mid-January. The

second recorder and lens were received at DREO in April 79.

The two extremely high resolution CRT's required to generate 4000 points across a five inch CRT trace were constructed under contract by Infodex Ltd.[4]. The contract was let on June 78 and the equipment was received at DREO by November 1978.

1.2 Design Requirement

No attempt will be made in this report to cover in detail the design requirements for this recorder as it is adequately covered by E.B. Felstead and G.E. Haslam[5], with the basic design parameters tabulated in Appendix B. The recorder was designed to record interferograms containing spatial information equivalent to a theoretical maximum image resolution, using a perfect correlator, of 7 x 20 metres.

1.3 Location of Equipment

The Satellite Receiving Station at Shoe Cove, Newfoundland was designated as the location for the Canadian SEASAT-A Ground Station. It was operated by a contract staff from NORDCO, Newfoundland for EMR. This station monitors and records imagery from a number of satellites, including SEASAT-A, using a 25 foot diameter dish for orbit tracking.

Additional recording equipment used on site during periods of Seasat's lifetime and currently available for playback were the High Density Digital Tape Recorder (18 MHz bandwidth) by Honeywell/Marinetta and Arvin Echo Science Analogue Tape Recorder (12 MHz bandwidth.)

1.4 Transportation of Equipment

The equipment was packed into eleven wooden crates for shipment from Mirabel by air to St. John's, Newfoundland on a dedicated wooden pallet.

Due to adverse weather conditions, the shipment completed its journey from Halifax via sea and road. It should be noted that the crates remained on the shipping pallet until St. John's and no damage was sustained.

2.0 MECHANICAL ASSEMBLY AND ALIGNMENT (50 KM SWATH RECORDER) AT SHOE COVE

A series of photographs (taken during the assembly by CIR Ltd. personnel at DREO) are used to illustrate the equipment and the mechanical assembly and alignment procedures. A diagram of the total recording system appears in Figure 1. The component parts of the recorder requiring stability

were assembled on half of a flat optical bench manufacuted by Newport Reasearch Corporation. The Film Drive electronics rack (by CIR) was mounted with other station electronic equipment. The power supply and the sweep circuitry for the CRT (Infodex) was situated on wheels beneath the optical bench.

2.1 Assembly

The sequence of assembly and alignment from dismantled parts is listed below in steps 1 through 17 accompanied by photographs wherever possible.

The optical system required particular care in aligning to produce the optimum recordings. Initial mechanical alignment of the spacing between CRT, lens, field flatter lens, and film surface was achieved using metal spacers provided by the contractor. Final accurate adjustments of focus, linearity of CRT sweep, exposure levels and resolution were achieved by examinations of test pattern images with a microscope and exposing film of test patterns under operational conditions. Micrometer locations are indicated in Figure 1 and tabulated in Table 1.

1. The NRC optical bench was shimmed to be horizontal to 0.001 inch in width and 0.005 inch longitudinally.

2. The six rail supports and three V blocks were arranged as in Figure 2 and the steel bars inserted (also Figure 3).

TABLE I

MICROMETER LOCATIONS AND SETTINGS

(See Figure 1)

		MM
CRT Front Focus	(CL2)	15.15-15.30
Lens Rotation (Range Balance)	(LR1)	10.90
Lens Horiz.	(LH3)	6.0
CRT Rotation	(CR1)	10.10
Lens Vert.	(LV4)	5.0
Lens Focus	(LL2)	17.50
V-Block Film Drive Unit	(FR1)	21.40

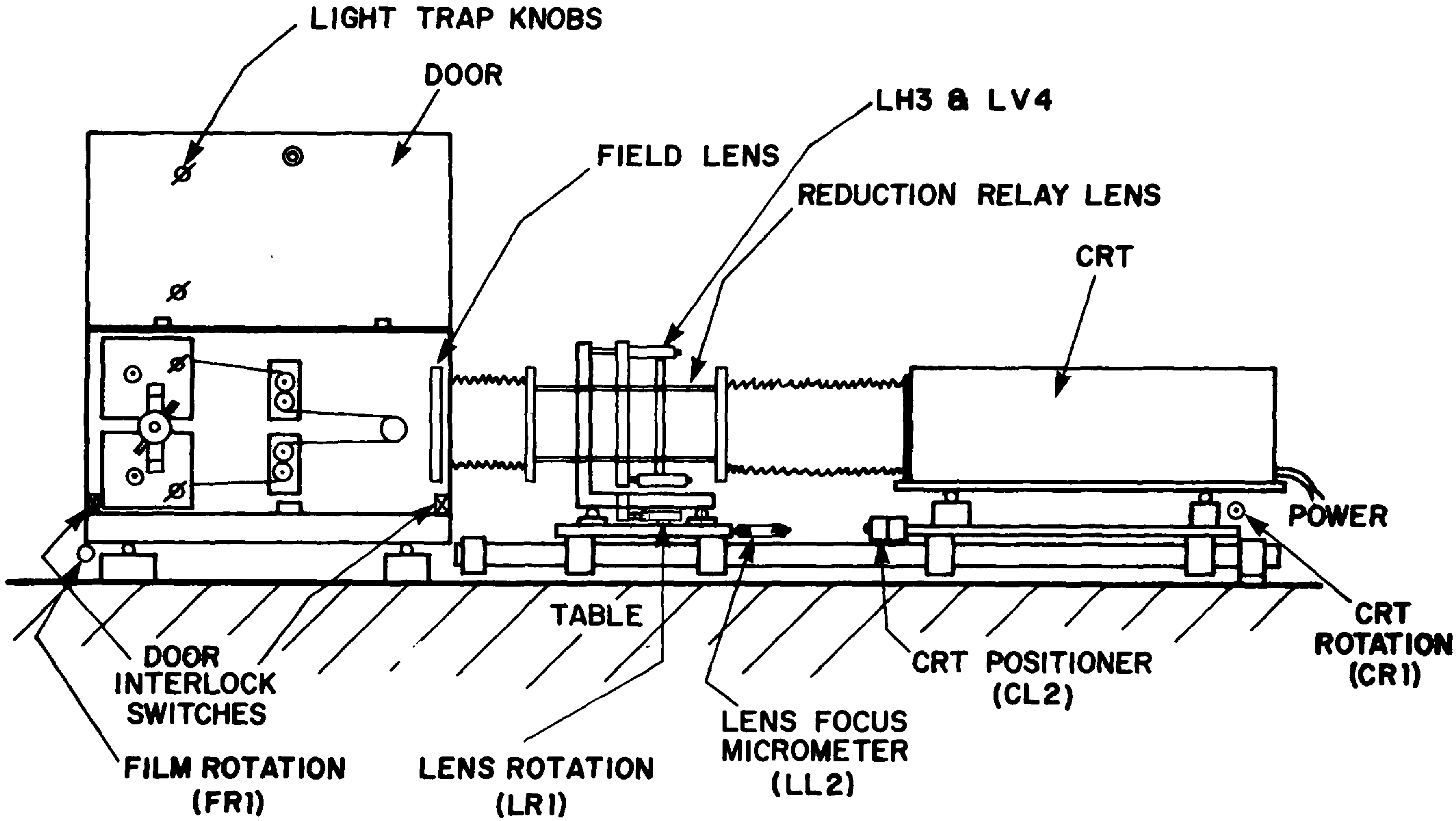


DIAGRAM OF FILM DRIVE ASSEMBLY, LENS AND CRT.

FIGURE 1

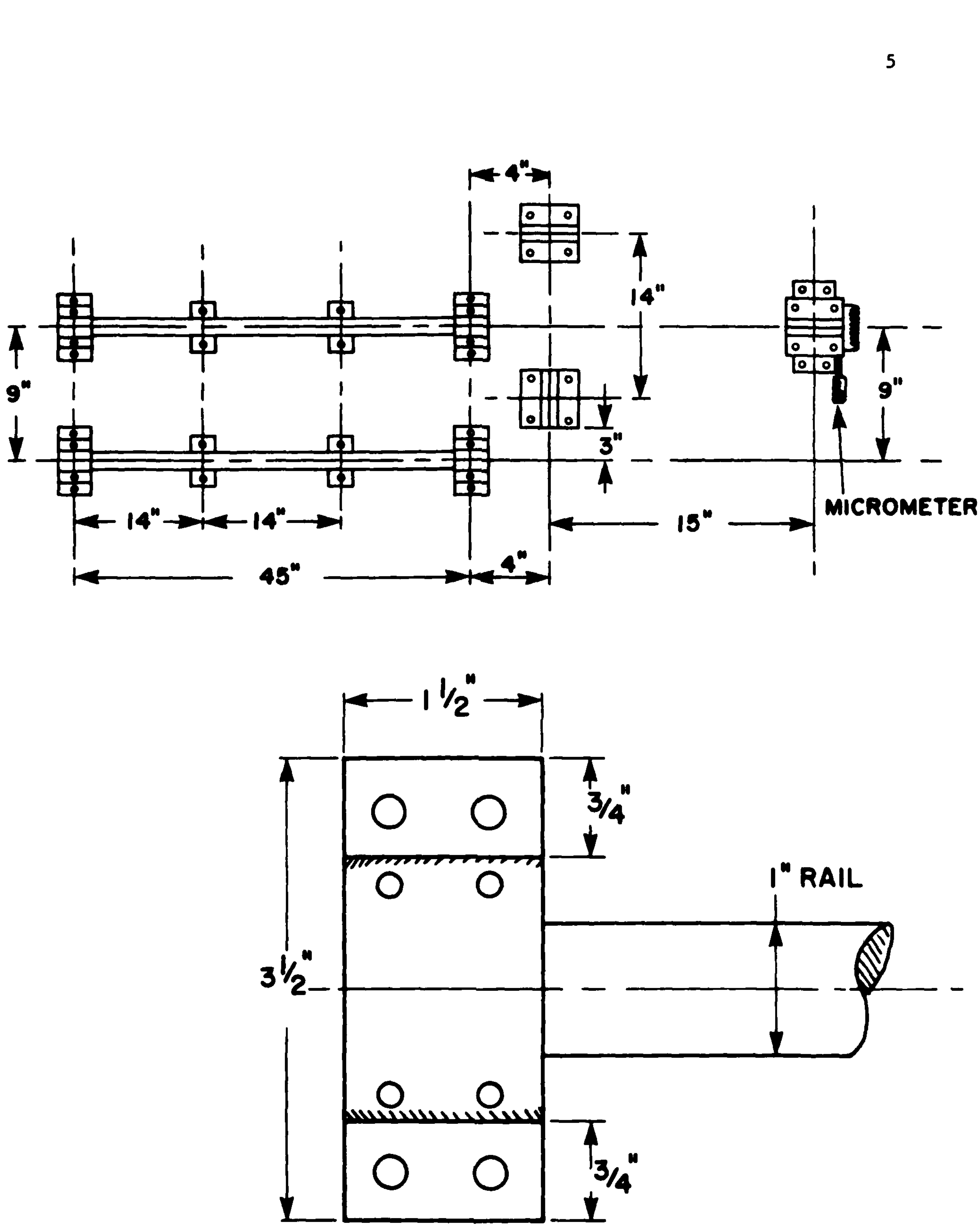


FIGURE 2 - PLAN OF RAIL AND V-BLOCK POSITIONS

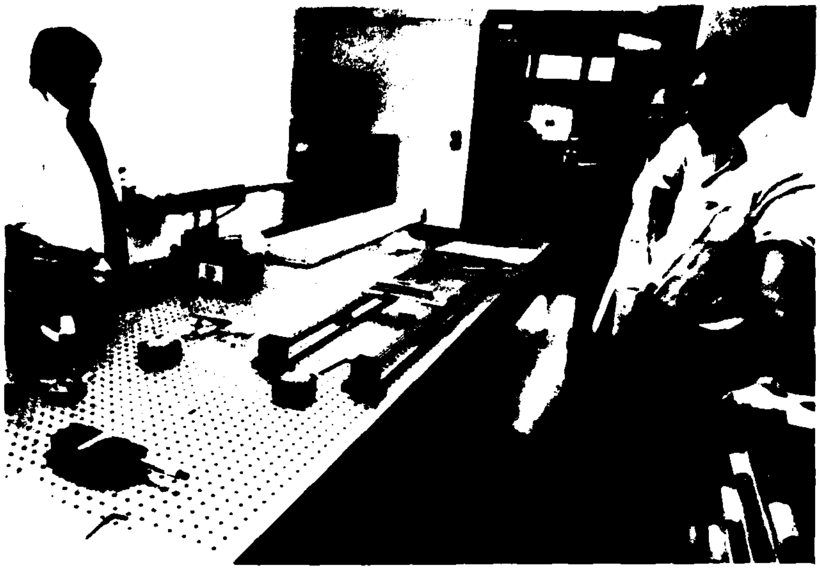


FIGURE 3 - PHOTOGRAPH OF NRC BENCH, RAIL AND V-BLOCKS SUPPORTS

3. The supports were shimmed when necessary to give less than 0.002 inch variation in horizontal level in width-down the total length of the rails similar to Figure 3.

FIGURE 4 - CRT AND LENS SUPPORT BASES

4. The support tables for the CRT and the lens were threaded on the inside rail and the rails horizontal level checked as in 3. (see Figure 4).

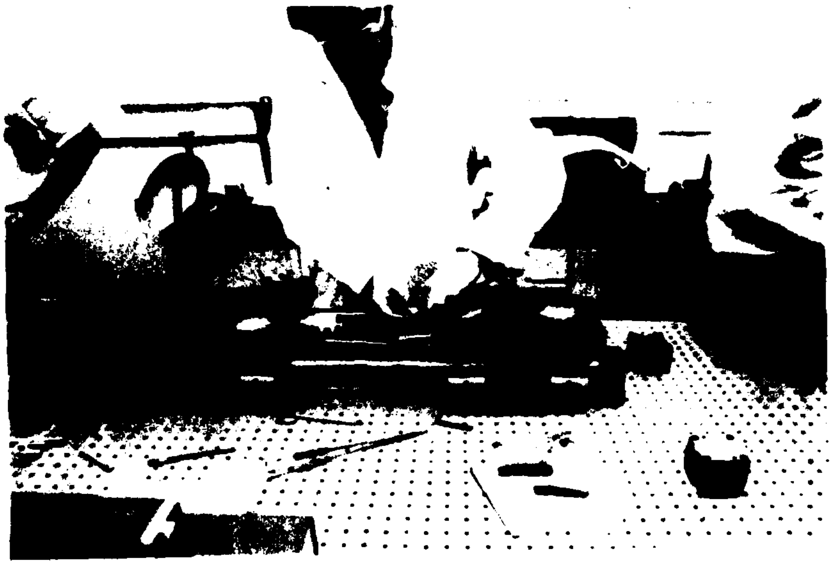


FIGURE 5 - FOCUSING MICROMETER INSTALLATION FOR LENS

5. The CRT focusing micrometer LL2 and its anchoring bar was attached to the CRT base, as in Figure 5.

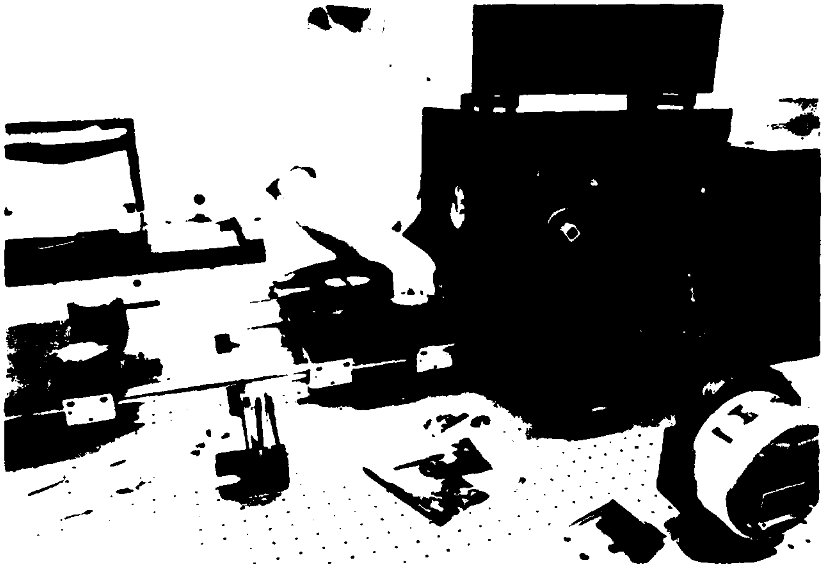


FIGURE 6 - FILM DRIVE UNIT POSITION

6. The Film Drive Unit was placed on the V blocks as in Figure 6.

FIGURE 7 - ALIGNMENT OF CAPSTAN

7. Alignment of the film recording capstan with the rail system was accomplished using a test jig and a 0.0005 inch dial gauge. The micrometer, FR1 on the V-block beneath the Film Recorder Unit adjusted the capstan to be normal to the rails to less than 0.001 inch and then locked into position. This measurement was made with the dial gauge over the 80 mm recording width of the capstan, as shown in Figure 7.

FIGURE 8 - ALIGNMENT OF CRT

8. The alignment of the CRT on its base can be accomplished in a manner similar to step 7, by reserving the test jig and running the dial gauge along the CRT face. The ends of the trace, 108 mm apart, were made equidistant from the test jig to within 0.001 inch by manipulating micrometer CR1 at the rear of the CRT. (see Figure 8). The face of the CRT was concave, showing a depression of 0.001 inches at the centre.

   Rotation of the CRT faceplace was made by shimming the appropriate front V block on the CRT table.

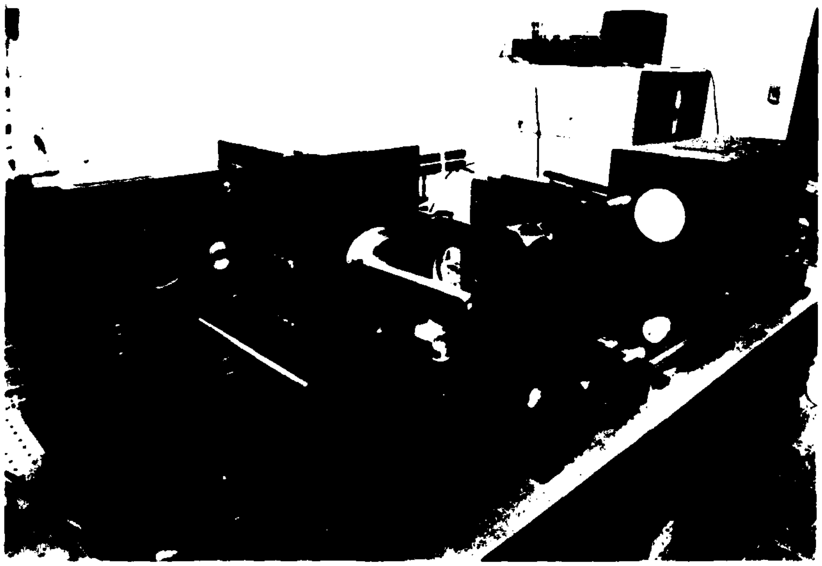


FIGURE 9 - TRANSFER AND FIELD FLATTENER LENSES INSTALLATION

9. The transfer lens with its carrier was installed onto the lens base and the field flattener lens attached as shown in Figure 9.

   The CRT was activated and the well-focussed horizontal trace (108 mm in length) was imaged by the system onto the capstan. A paper sleeve with an 80 mm line drawn tangentally along the capstan was adjusted to represent the position the image should occupy. Adjustments of transfer lens focus and image height were made for initital image positioning using the manufacturers metal spacers for CRT, transfer lens and field flattener lens positions so as to fall on the 80 mm line.

   The drawn 80 mm line was rotated to the rear of the capstan to the same image height as before. The height of the line was checked with a bench gauge.

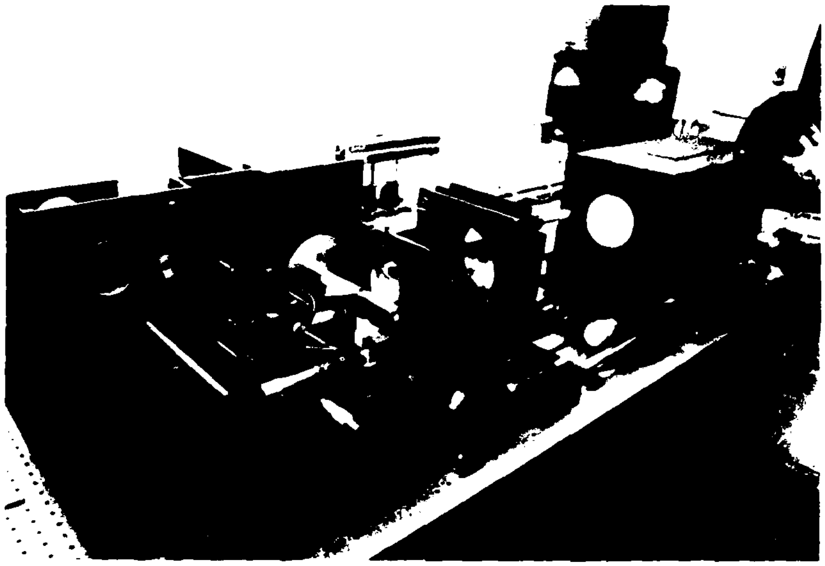


FIGURE 10 - MICROSCOPE FOCUS ON CAPSTAN

10. The special travelling microscope was set into the Film Drive Unit (Figure 10) occupying the area where the film tension rollers are usually located. The microscope was focussed onto the back of the capstan with the 80 mm line (Step 9) and adjusted so that it remained in focus and in vertical and horizontal field while the microscope tranversed the full 80 mm of the line. This was accomplished by using the adjustment screws provided on the microscope stand. The microscope should be rigid. The micrometer focus reading was noted.

    The capstan and drive motor were removed enabling the microscope to be refocused nearer to the lenses at a distance calculated to be the line in space where the image should be located. (The capstan diameter plus the paper sleeve thickness and the film thickness - 25.44 mm).

11. The lens and CRT were finely adjusted so as to give a demagnification of 1.36:1 with a sweep length of 79.3 mm. Final mechanical focusing at this stage was made by adjusting the CRT focus using micrometer CL2 to bring the total image into sharp focus without moving the microscope focus or lenses.

12. The position of the image at the microscope image plane was adjusted also by movement of the micrometers and on the lens carrier. The height of the image was manipulated with height or vertical control on the CRT control electronics and the screw in base of the lens. The focus of the trace at its extremities was controlled by micrometer LR1 at the base of the lens carrier. (see also Appendix E). Rotation of the trace could only be obtained by shimming the base of the CRT.

13. When the linearity of the CRT sweep combined with the lens transfer characteristics had been adjusted using the 21 DOT GENERATOR BOX (Appendix D), the next step was taken.

14. The microscope was removed, the film tensioners, the capstan motor and encoder replaced and the film cassettes installed. The outer housings' plates of the Film Recorder Unit were replaced.

15. The final focussing and demagnification adjustments were made with the CRT Base Micrometer CL2 and the lens micrometers LR1, LH3, LV4 and CR1 and the resulting focus changes were recorded on film.

    Various electronic test patterns were recorded using high frequency video information (10 MHz to 20 MHz sine waves). The film recordings were evaluated using Fourier Transform techniques, (Appendix E) to establish best focus and frequency response across the CRT image.

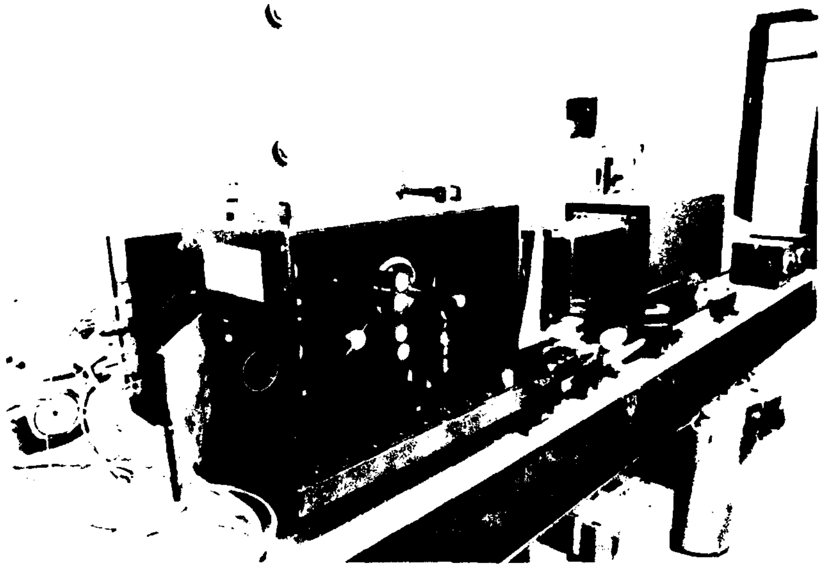


FIGURE 11 - CRT/FILM DRIVE UNIT ASSEMBLY
AND BELLOWS INSTALLATION

16. Bellows between the CRT/Film Drive Unit and the lens were incorporated to prevent interference from background light as shown in Figure 11. Figure 13 illustrates the control panel at Shoe Cove.

17. Care must be taken to install the pulse encoder so as to not load the film drive motor. (Figure 13)

18. Photograph 15 shows the entire optical recording system on the optical bench at Shoe Cove.

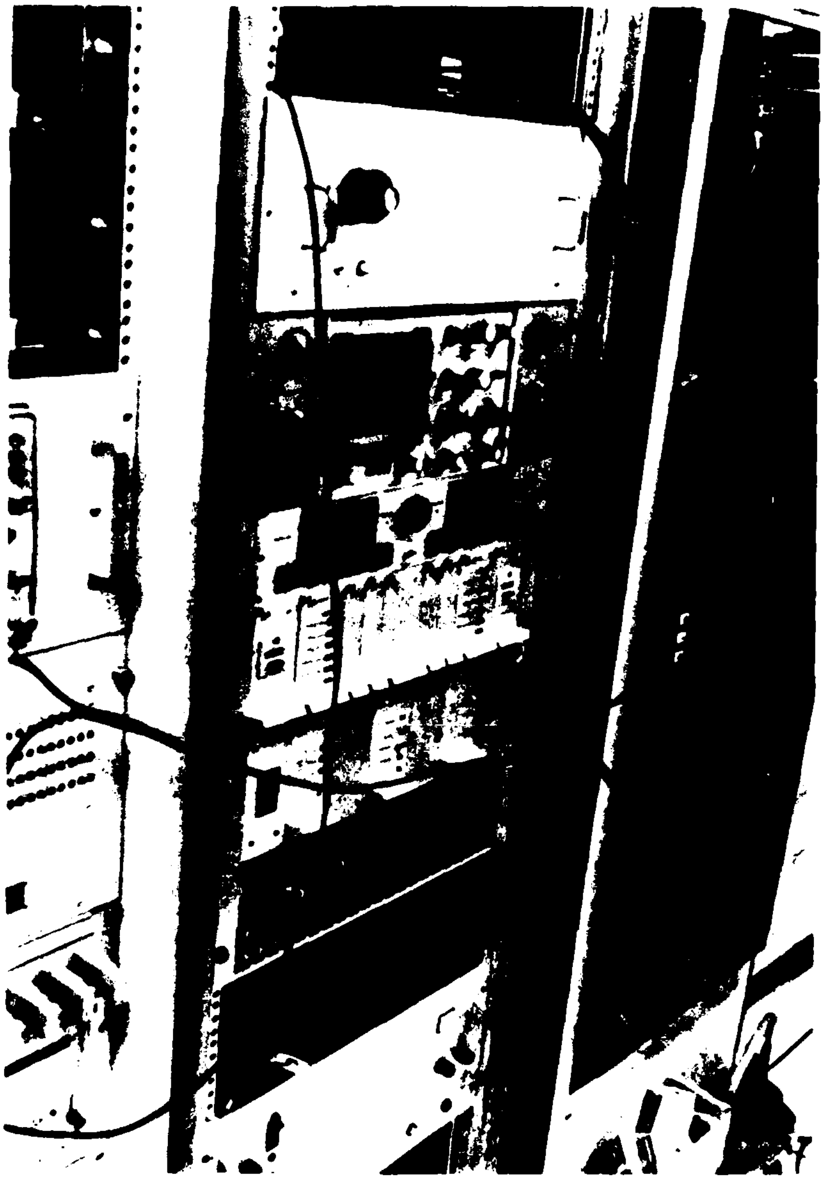


FIGURE 12 - CIR CONTROL PANEL FOR TWO CRT [illegible]

3.0 ELECTRICAL OPERATIONS OF OPTICAL RECORDER SYSTEM

3.1 Film Drive Control Unit (FDCU)

The operation of the Film Drive Unit was controlled from a rack (FCDU) of electronics provided by CIR Ltd.

The control panel provided a method of running short lengths or continuous lengths of recording film at extremely accurate velocity. A table of the operation is shown in Appendix A, Table 1, also Figure A-3 and a photograph in Figure 12 illustrates the panel.

Featured on the electronic FDCU were push button operation for stop, pause, run, leader, and standby, with buzzer and light alarm systems to announce the failures of film drive, phase lock, tension operations and air pressure loss. Block diagrams of the operation are also presented in Appendix A.

The capstan was suspended by an air bearing. Audible/visual warnings when air pressure was lost was essential to avoid damage to the air bearing.

The Film drive unit operated with five inch film in 100 foot lengths using RAR 2498 which should be loaded and unloaded in complete darkness. Cassettes were used to load the film into the film drive area with light traps to prevent exposure. The light traps were released when the lid of the Film Drive Unit was closed by using locating knobs on the lid. Tension in the film was maintained by two pairs of tension rollers shown clearly in Figure 11 and Figure A 2.

3.2 Air Bearing and Encoder

The Film Drive Unit owes its precision to the capstan being driven through an air bearing and the encoder controls the capstan motor velocity (see Figure 13) and thus the film to 40 mm/sec with a maximum velocity change of ± 0.06%.

The air bearing was driven from a compressor located outside the building through a valve arrangement (Photo 14). A pressure of 60 lb/sq. in. was maintained. A reserve bottle of compressed nitrogen was automatically connected to the system in the event of a power failure. The air system was also attached to the NRC optical bench which had air operated vibration isolation legs. (Figure 15).

3.3 CRT Power and Deflection Unit

The other electronic control section of the recording system besides the FDCU was the Infodex CRT power supply, control electronics and the DREO

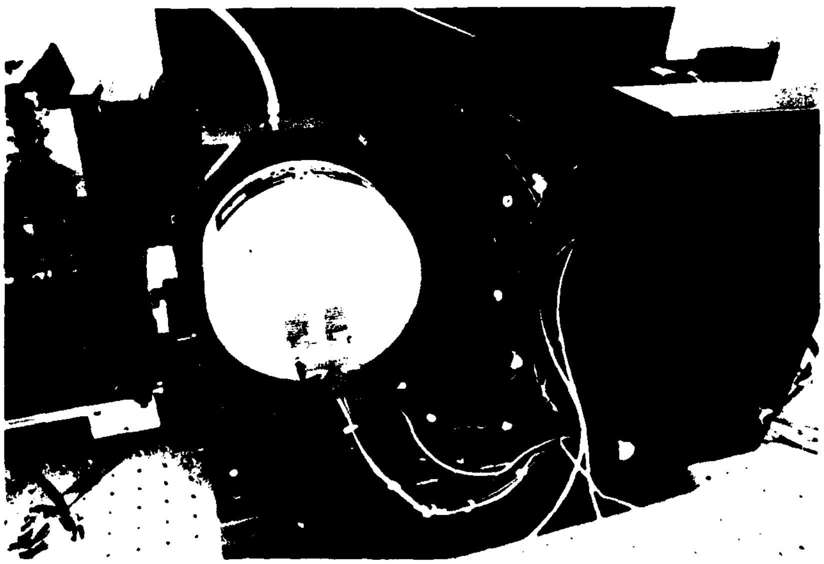


FIGURE 13 - ENCODER, AIR LINE, FILM TENSION & MOTOR DRIVE

Signal Interface Unit (see Figures 12 and 15).

The high voltage power supply, supplied by Infodex experienced regulation problems. However, substitutions and modifications corrected the problems which were found to be produced by Newfoundland Light and Power line fluctuations.

The CRT's performance was evaluated and adjusted to specifications by observing the modulated trace with a microscope and by recording films with the total system operational (Appendix D and E).

Due to noise on the trace the vertical deflection and vertical linearity correction amplifier boards were completely removed and the recorder operated satisfactory without them. Block diagrams of the equipment used in the total recording system with signal levels appears in Figures 16 and 17.

3.4 Equipment Testing and Alignment

3.4.1 CRT Focus

The alignment and focusing of the CRT spot was completed prior to any testing according to the procedures in Appendix D and E.

It was considered necessary to carry out this procedure if new CRT or alignment components were installed.

3.4.2 CRT Linearity

The trace of the CRT was adjusted for linearity using a Test Generator Box (Appendix D) which was able to modulate the CRT trace and generate a pattern of 21 dots across the CRT face of the Infodex Scope. (Figure D-1). One dot was in the centre and eleven others were equally spaced on each side of centre. The pattern was generated from a precise countdown of a 5.00 MHz oscillator to 125 KHz, then adjusted to a 0.8 μsec duration positive going pulse. This video was gated with the CRT unblanking pulse and the 21 dots adjusted to a sweep length of 163 μsec. The resulting dot pattern on the screen allowed for segment by segment adjustment of the linearity correction circuit contained in the Infodex Power Supply Card Rack. By adjusting the appropriate potentiometers on this board, the sweep rate could be changed from dot to dot while visually superimposing the bull's eye pattern mask provided, with a microscope (20X power), (Appendix D). Any pin-cushion distortion was minimized. (See also Appendix D for Resistor locations and Linearity adjustment sequence.)

The dot pattern also allowed for precise electronic focusing of the electron beam in order to correct for deflection defocusing on a flat-faced CRT due to magnetic deflection.

FIGURE 14 - AIR BEARING PRESSURE CONTROL AND COMPLETE CRT /FILM DRIVE UNIT (SHOE COVE)

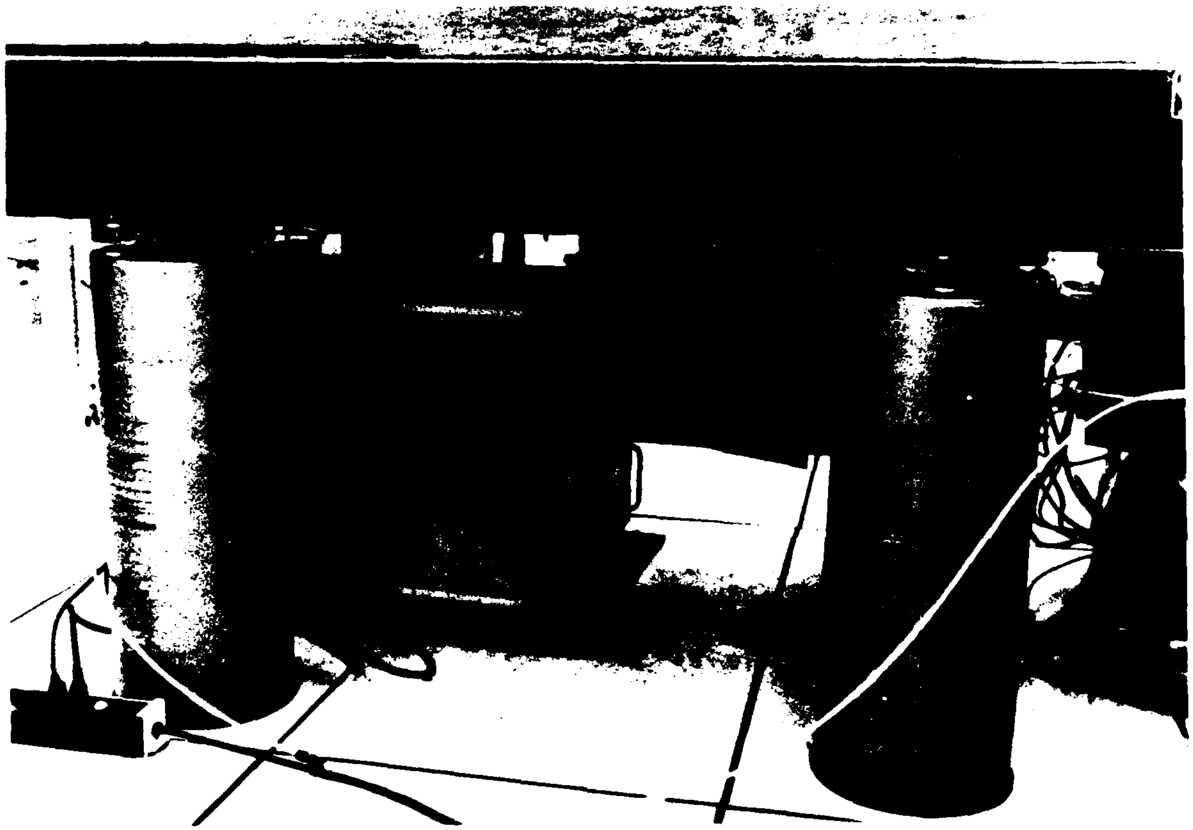


FIGURE 15 - NRC ISOLATED TABLE & INFODEX POWER UNIT

Figure D-1 in Appendix D shows the alignment of dot and 'bull's eye' pattern.

This test checks the total sweep linearity to less than 0.01% when all the spots are aligned with the centre of the appropriate bull's eyes.

3.4.3 Lens Linearity

The test sequence applied to CRT Linearity Section 3.4.2 was also applied at the image recording plane as described in Mechanical Assembly Section 2.1, item 3, to compensate for any non-linearity in the relay lenses. The alignment of the image on another bull's eye pattern (21 DOT-reduced 1.36:1) was adjusted segment by segment where necessary.

4.0 DATA SIGNAL PATH

The data signal could be originated from either one of three sources, the SEASAT Satellite, (real time) the HDDT or Video analog recorders. All sources provide a complex data signal containing time codes, coherent trigger, clock pulses and raw data (video) to construct the desired interferograms.

This data was manipulated by the various circuits to control the optical recorder. The path of the data is outlined here with references for detailed information on the various sections.

The block diagram in Figure 16 shows the sequence of equipment and the typical signal strength of the video signal.

A description and evaluation of the electronic systems involved is considered beyond the scope of this report but the equipment is discussed generally.

4.1 Real Time SAR

Due to the delay in installation of the optical recorder equipment, no real time data was recorded. DREO Back-up Optical Recorder was installed at this time and real time data was recorded on 0 - 50 km range. Had the new optical recorder been available it would have been connected to the input of the 22 MHz bandpass filter (Figure 16) from the SAR demodulator.

4.2 HDDT Recorder

This magnetic tape unit manufactured by Honeywell with SAR ancillary[5] equipment (by Martin Marrietta) was capable of recording on 39 digital channels, at a video bandwidth of 18 MHz, with a bit rate of 120 M Bits/sec, i.e. most of the 21 MHz signal received from the SEASAT SAR. Another channel was used for the housekeeping data - coherent trigger, time code and clock pulse. The range swath of 100 Km was recorded.

The playback of the data into the optical recorder was very reliable and with a low bit error rate. The video signal strength for most recording was 150 to 200 M volt p.p.

The playback output was fed into the DREO Interface. (Figure 17)

4.3 Video Analog Recorder

The video analog recorder manufactured by Arvin Echo was a 6 MHz two channel recorder. It was installed at Shoe Cove to record the initial passes of the SEASAT SAR when neither the HDDT recorder or the DREO Back-up Recorder[2] were operational. An electronics package designed at DREO allowed each channel to record 6 MHz of signal to effectively create a 12 MHz recording.

The same video and pulse data was stored on tape as in the HDDT (except for Bandwidth of 12 MHz) and connected through an interface system designed for the DREO Back-up Optical Recorder.

4.4 Interface Unit (HDDT only)

All signals from the HDDT recorder were applied to the Interface Unit to interface to the optical recorder. Figure 14 shows a schematic of this Interface Unit, and Figure 16 shows its position in the recording system.

1) Video Preamplification

To prevent sideband modulation and to contain the bandwidth between 2.0 and 22 MHz a Bandpass Filter was installed at the video input. The video level was controlled using a variable 10 dB attenuator in front of the 26 dB Avantek amplifiers. A power splitter was required to provide video to two CRT recorder inputs (one not used) and a test point.

2) Coherent Trigger, Sample Clock and Delay Circuit

Delays of up to 180 μsec in the coherent trigger were designed to display predetermined sections of the Range sweep. Five set delays were selectable using a dial on the front panel. A sweep duration of 163 μsec generated an interferogram on film that would correlate into 50 km range.

The sample clock at 45.53 MHz was obtained from the HDDT and was used to develop the delay increments.

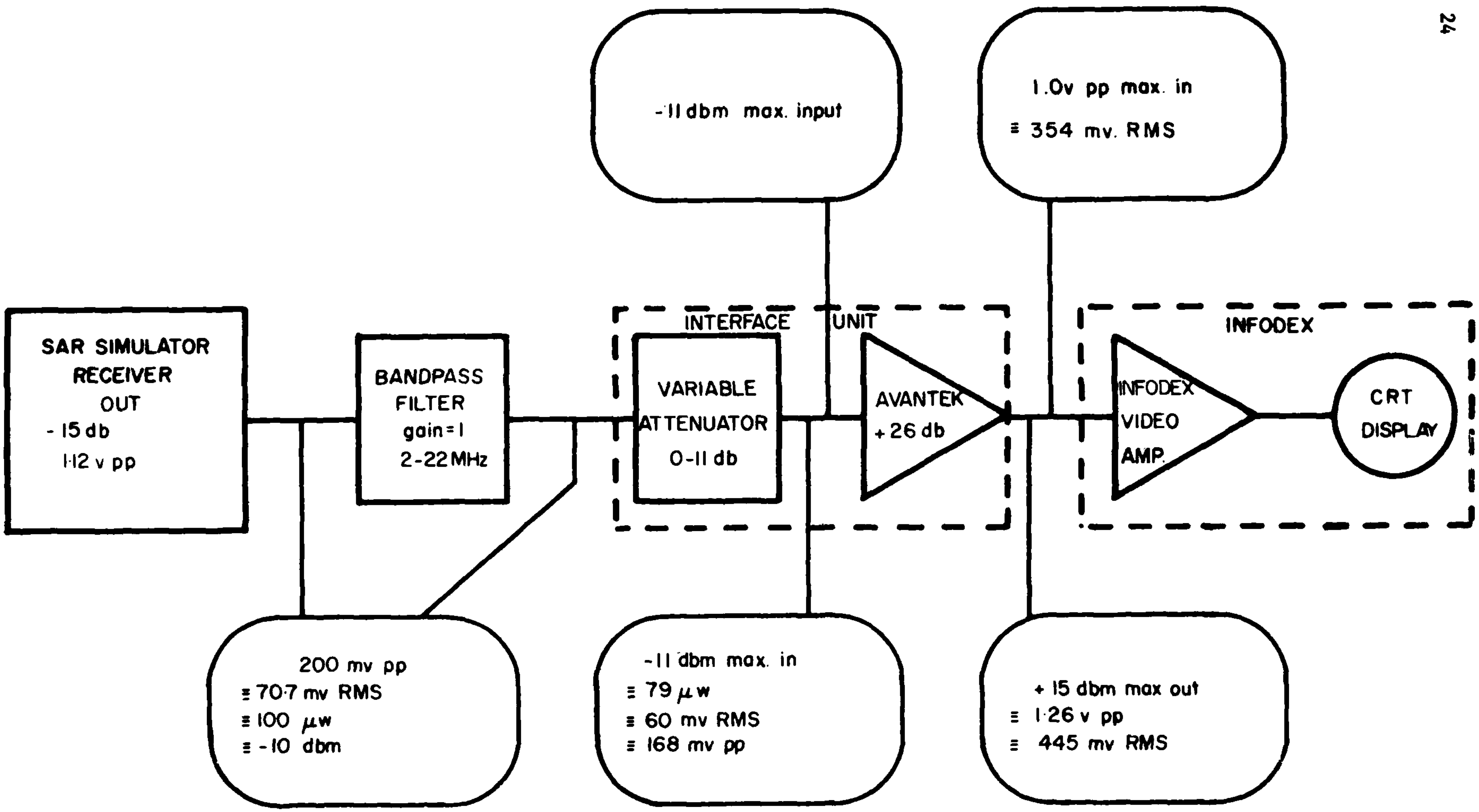


FIGURE 16 - BLOCK DIAGRAM SIGNAL STRENGTHS AND PATHS FOR RECORDING FROM HDDT RECORDER

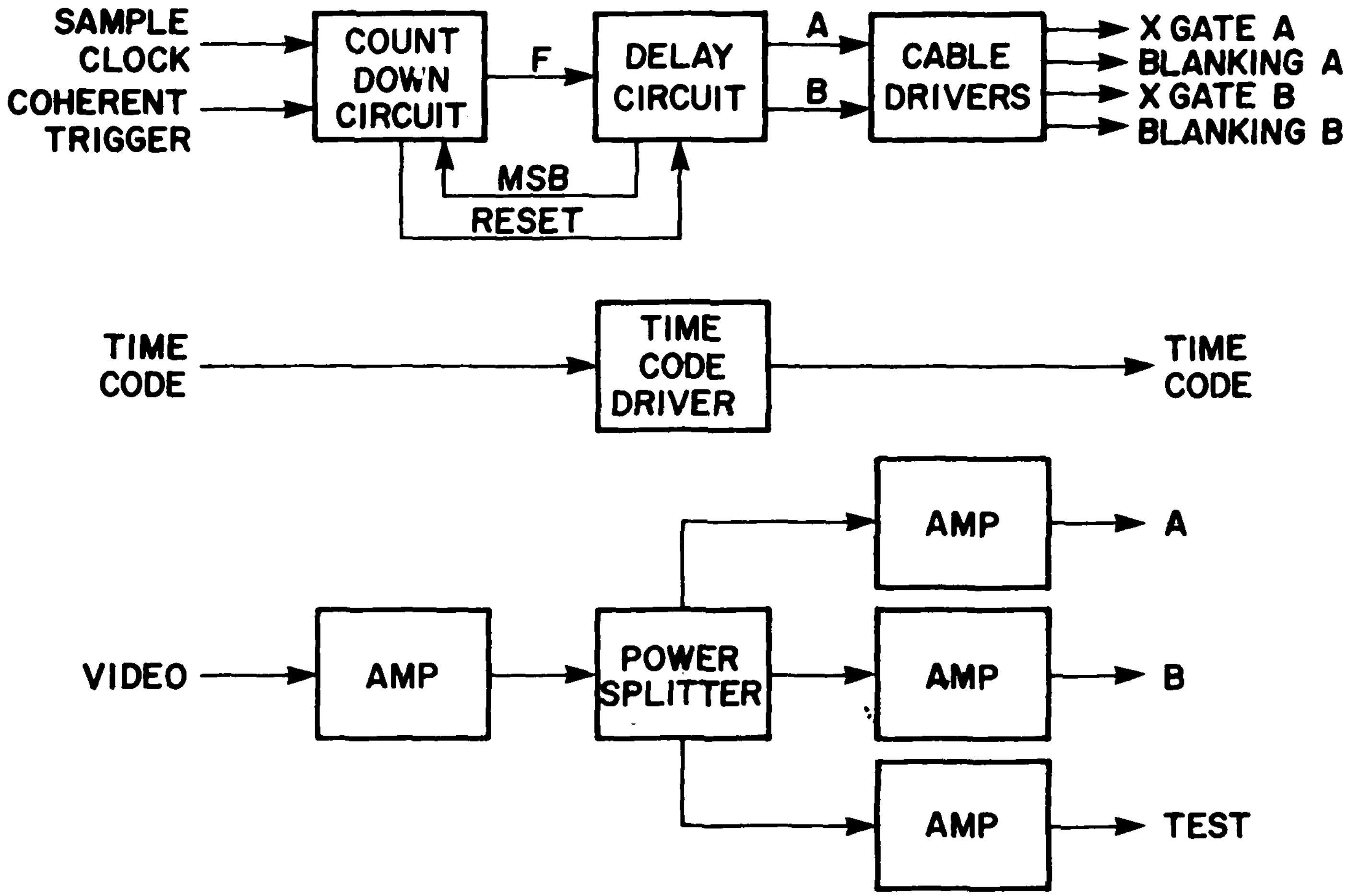


FIGURE 17 - INTERFACE UNIT

3) Time Code Generation

The time code was recorded on channel 40 of the HDDT from a time code generator at Shoe Cove during the passes of the satellite. Figure 18 shows the time code format used and recorded on each side of the interferogram. A time code driver circuit in the Interface Unit was used to drive the LED's inside the Film Drive Unit. The LED's created code patterns and an unmodulated reference line approximately 10 mm in from each edge of the film. (See also Figure 22).

The time code was used to identify image location on each interferogram from the day number and standard time.

4.5 Video Amplifier

The video amplifier supply by Infodex (located in the CRT cabinet) was a D.C. pulse amplifier as shown in Figure 19. The amplifier was modified to A.C. coupled, as shown in Figure 20, to improve beam modulation. However, the modified amplifier was not found to provide sufficient voltage swing to drive the CRT fully on and off. The amplifier was then further modified to the design shown in Figure 21 which achieved 37 volts peak-to-peak at 22 MHz.

4.6 CRT Response to the Signal

The signal data was eventually presented on the CRT face plate where the response of the P11 phosphor was determined by techniques discussed next in section 5.0.

5.0 OPTICAL SIGNAL PATH

5.1 Relay Lenses

Under a subcontract to CIR Ltd., M.M. Patenski designed two lenses with 1.36:1, demagnification for this recorder. A subcontract was issued to Applied Physics Specialties Ltd., Toronto to manufacture the lens elements. It was assembled by CIR Ltd. under Patenski's guidance and designed to have a speed of f/2.0 and a focal length of 170 mm.

Evaluation by M. Failes (CIR) showed that initially neither lens gave satisfactory MTF (modulation transfer function) at the outer limits of the lens at 40 line pairs/mm. The second production lens was re-assmebled to closer spacing tolerances, more attention being given to the element thicknesses and spacing. Number two lens also was assembled with an isis for f/number reduction and hence resolution enhancement.

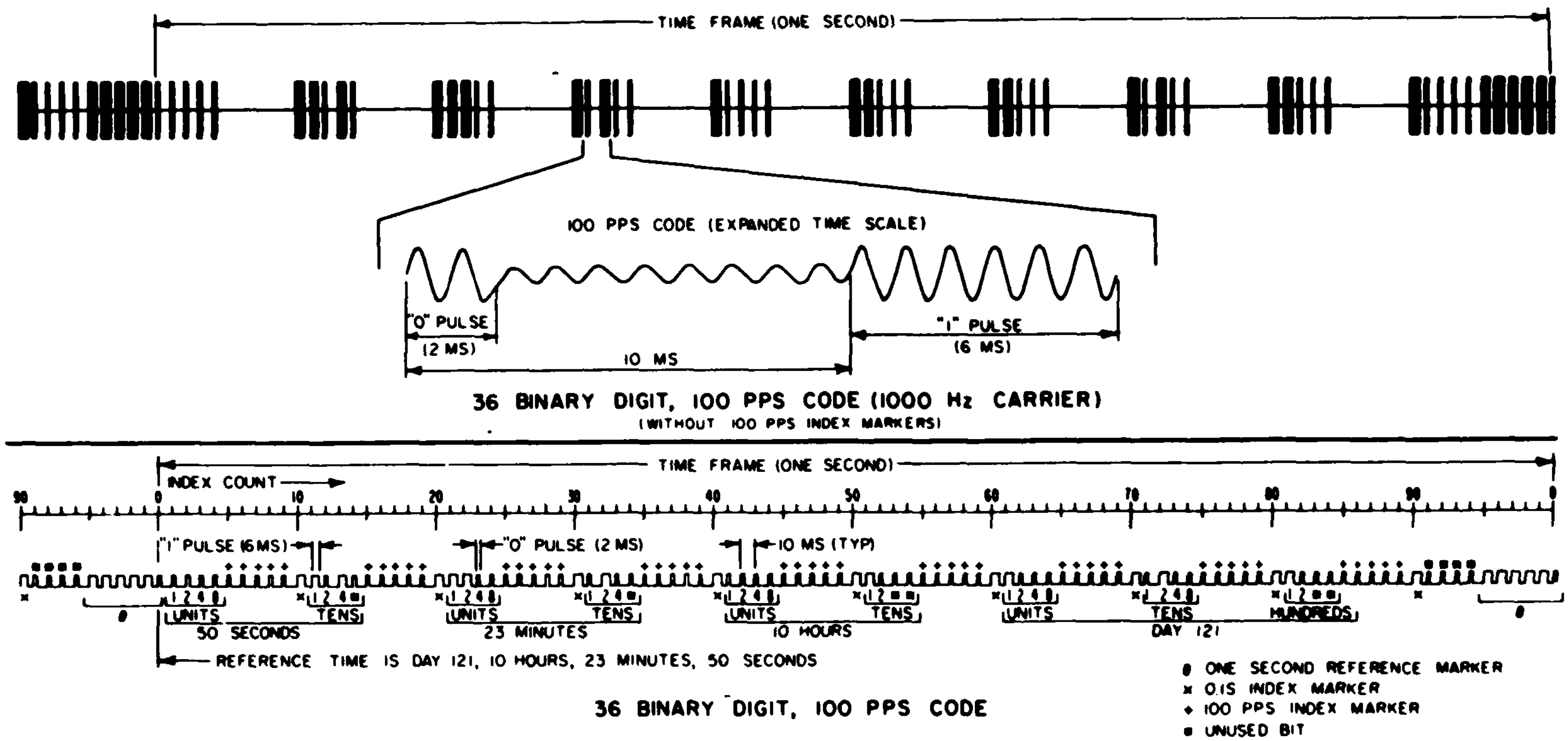


FIGURE 18 - TIME CODE FORMAT

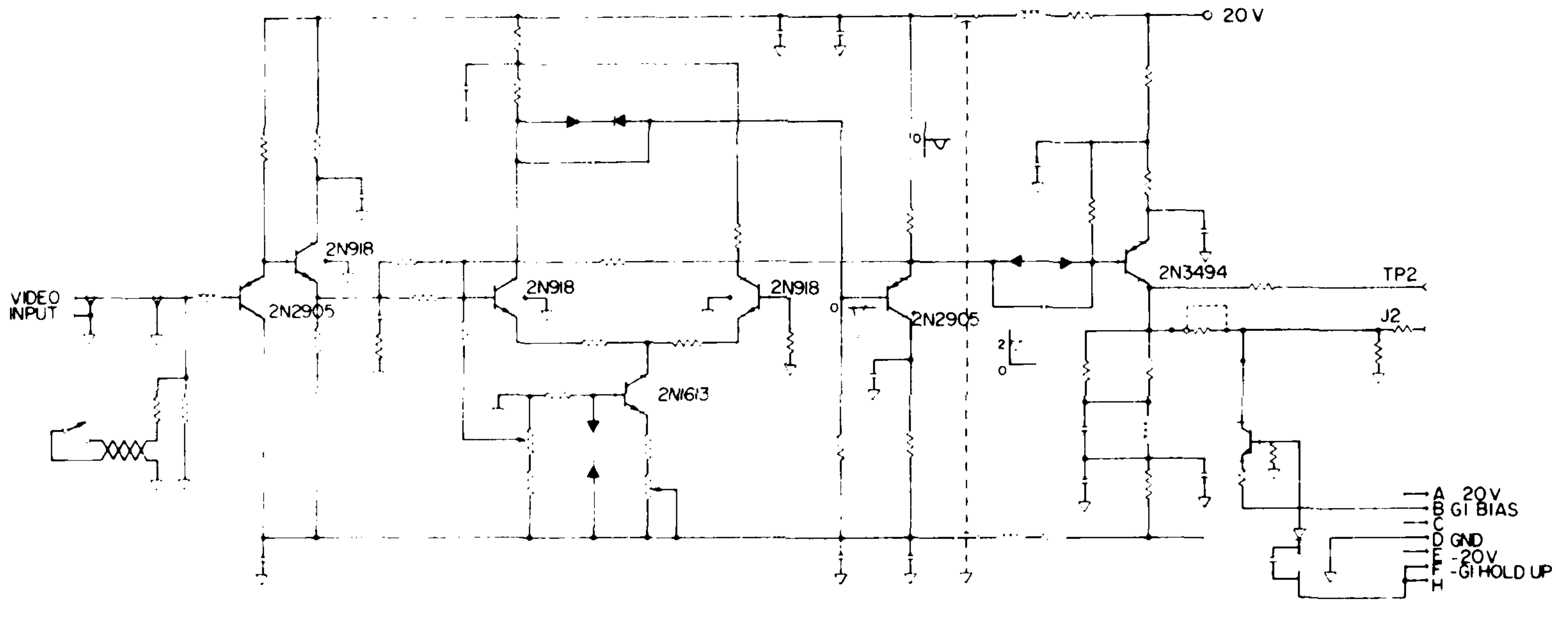


FIGURE 19 - VIDEO AMPLIFIER (INFODEX ORIGINAL)

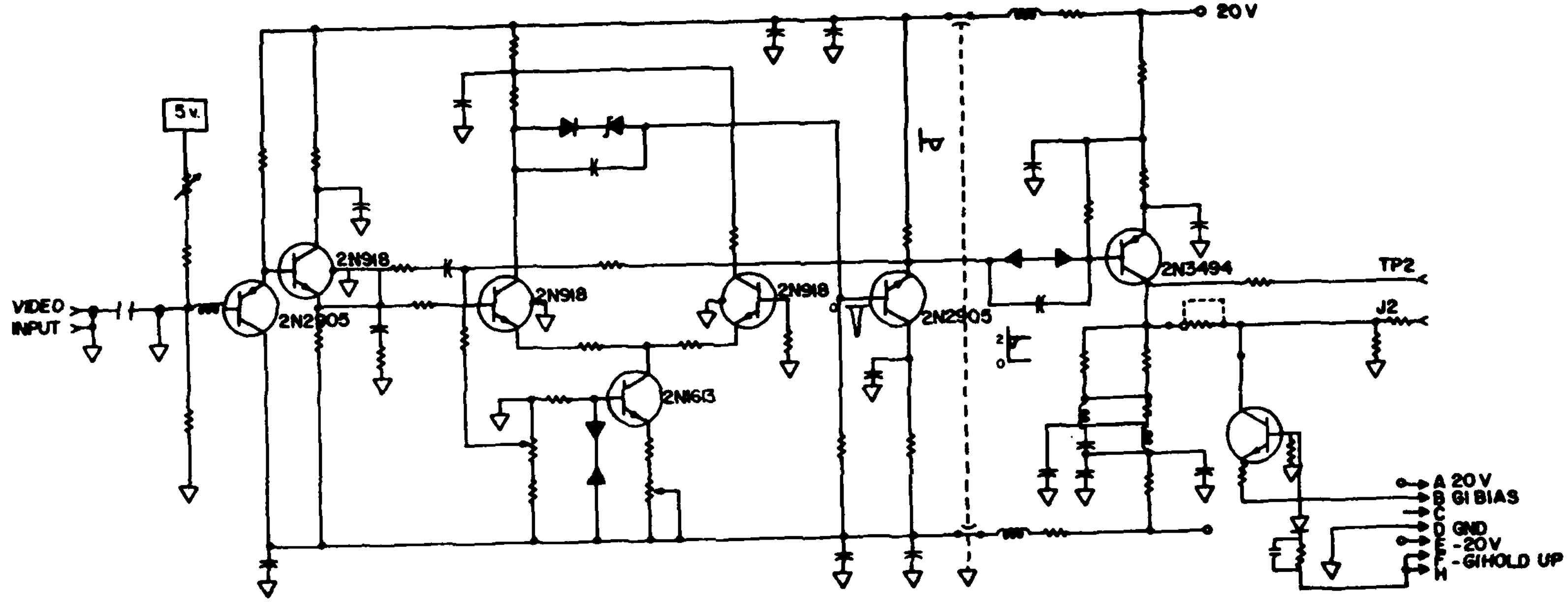


FIGURE 20 - AC COUPLED INFODEX VIDEO AMPLIFIER

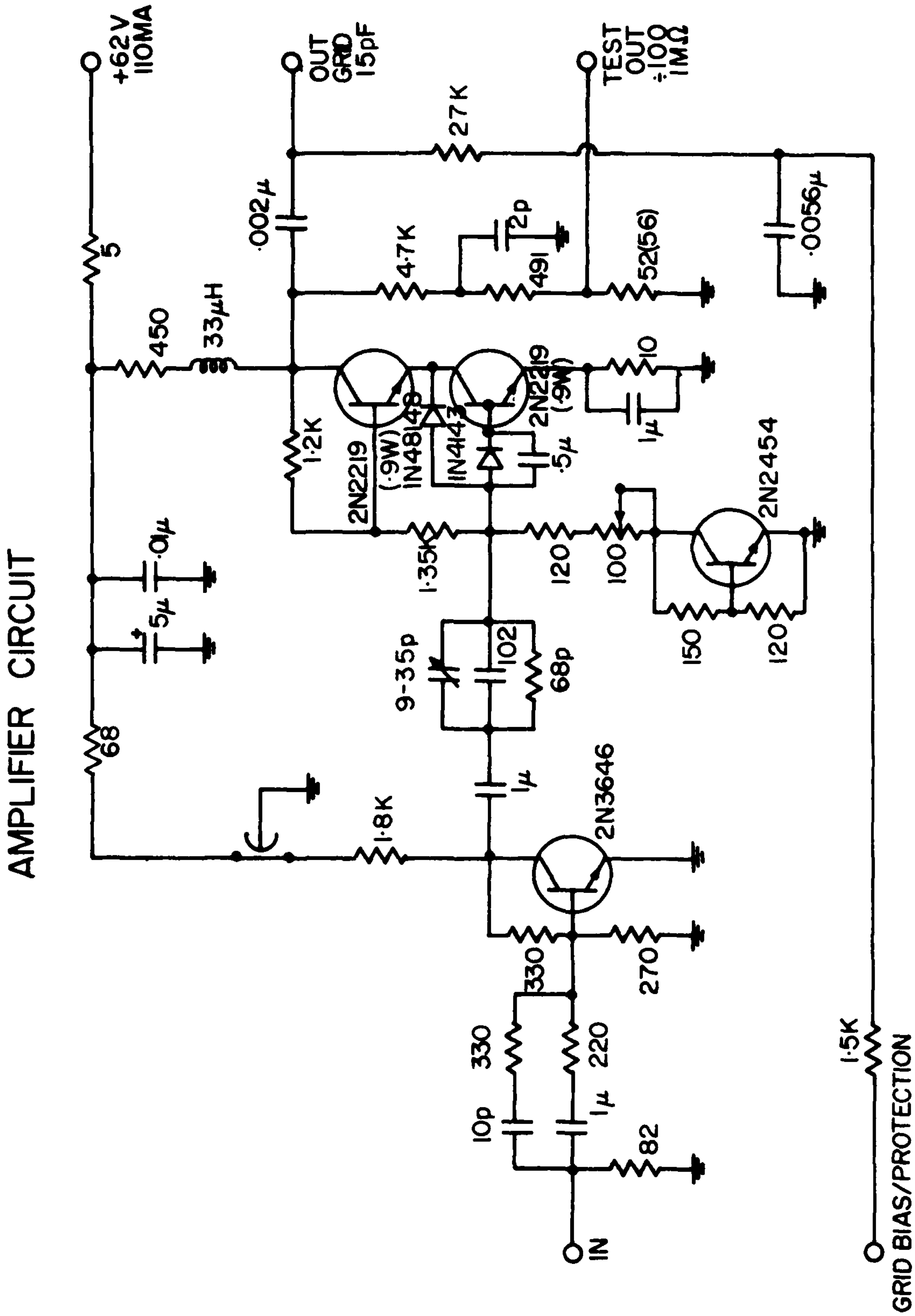


FIGURE 21 - AC COUPLED DREO AMPLIFIER

The second lens was again examined at 40 line pairs per m.m. and proved to be considerably improved but low M.T.F. at the outer edges of the lens was evident (MTF = 20%). This lens was used for all subsequent interferogram recordings at Shoe Cove.

The system also incorporated a Field flattener lens to aid in achieving at flat image at the recording film plane. The lens mounting enabled some latteral repositioning to be achieved.

5.2 Film Drive Unit Film

The film drive system whose operation is described in an Operator's Manual, Appendix A, could use any available five inch wide film. A detailed description of the electronic controls governing the operation of the film transport may be found in the CIR Ltd. Manual. The film thickness however should be taken into account as a defocussing of the image could result if compensation is not made.

5.3 Imaging

5.3.1 Image Linearity

Sweep linearity adjustments were made using techniques described in Section 3.4.2 to compensate for the lens distortions. The observing microscope was located inside the Film Drive Unit with the capstan and tension rollers removed (see Figure 10). A demagnified 1.36x bull's eye pattern located at the image plane on the XYZ translation stage was observed with the trace image superimposed. The sweep linearity from dot to dot was adjusted where necessary using the appropriate poteniometers in CRT deflection board. (X-on axis Linearity Board A 4). Appendix D describes the operation in detail.

5.3.2 Image Quality

Tests were made on film using the Test Generator Box to determine the image quality in the field installation. This was to ensure that the optimum static and dynamic focus, linearity correction, and maximum frequency bandwidth were obtained when the two systems, optical and electronic, were brought together.

The test Generator Box produced the necessary 163 μsec sweep and 1600 Hz PRF trigger pulses, from either external source or the built-in 5.00 MHz oscillator. The test circuitry also made video frequencies TRIG, of 5.0, 10.0, 15.0 and 20.0 megahertz available with 50% duty cycle, square or sine waves.

The Fourier transforms of the test films were examined and the intensity of the spatial displacement of the discrete frequencies from the DC was measured with a power meter and its efficiency calculated (Appendix E).

The changes of lens focus, image balance, film exposure, levels of frequency response and CRT parameters were evaluated also using F.T. Transform methods.

Examples of typical interferogram film are illustrated in images shown in Figure 22 together with an illustration of the Fourier Transform (F.T.) obtained from a 18 MHz frequency test (Figure 23).

More details of the determination of the operated settings of CRT focus and CRT parameter are given in Appendix E using Fourier Transform techniques.

The results of the Fourier Transform test are illustrated in Figures 24 a) and b) shown Cathode Bias and CRT Focus micrometer positions were established by the peak efficiences.

5.4 Film Types

The specific requirements for a recording film was evaluated by E.B. Felstead[5] and in a report issued by Capt. Webster CFPU[6], Rockcliffe, subsequently led to a choice of Kodak RAR 2498. The availability of more CRT light intensity than orginally calculated made the use of other high resolution RAR films feasible. The processing of RAR 2498 was done by initially Reproduction Centre of National Air Photo Library using Versaflo A chemicals. This chemical was second choice to 885 chemistry recommended in CFPU report. The reason was the unavailability of versamat equipment using 885 chemistry at NAPL. Later films were processed with 885 chemistry at CFPU, Test and Evaluation Unit, Rockcliffe CFBO (N), Ottawa.

5.5 Optical Filters on CRT

In an attempt to improve the resolution of the CRT, Optical filters with properties of narrowing the bandwidth of the phosphor emmission and possibly reducing chromatic aberration were used at the CRT face plate.

The resulting films showed reduced intensity and no improvement in efficiency indicating that little chromatic aberration was occurring or improved chromatic aberration was traded for insufficient intensity.

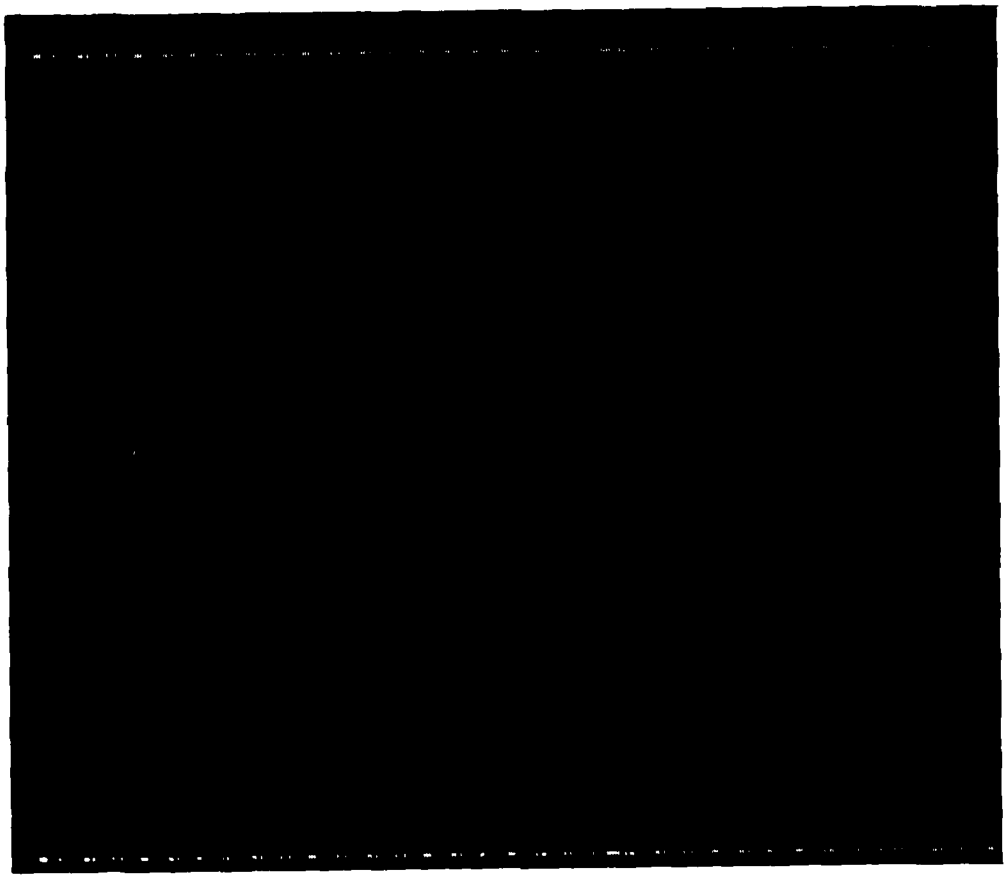


FIGURE 22 - PRINT OF TYPICAL INTERFEROGRAM WITH TIME CODE ANNOTATION

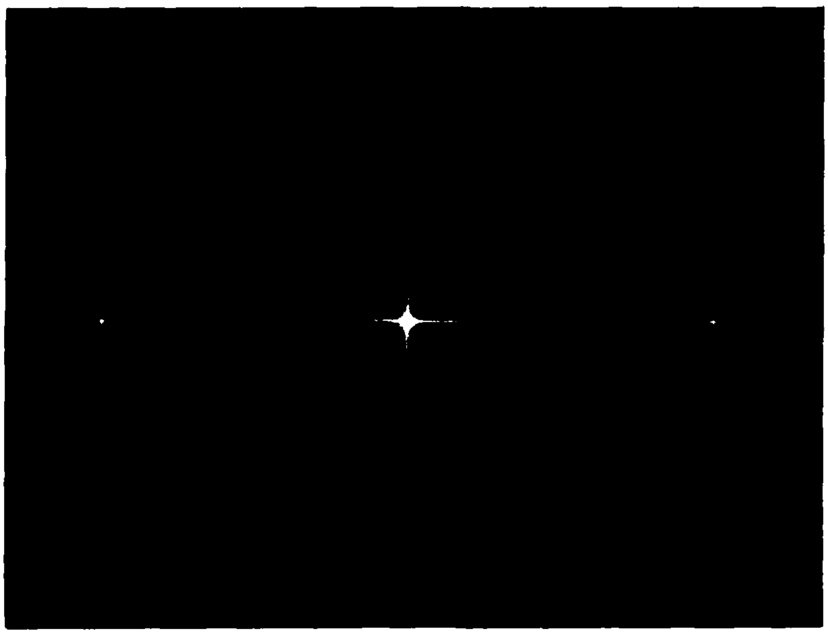


FIGURE 23 - FOURIER TRANSFORM OF TEST FILM (18 MHz)

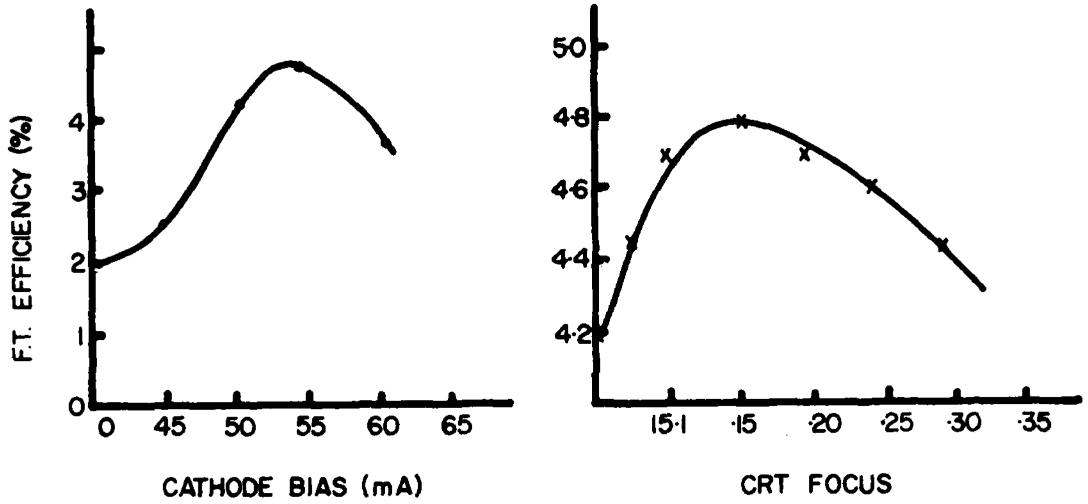


FIGURE 24

a) CATHODE BIAS VS EFFICIENCY OF TEST FILM GRATING

b) CRT FOCUS SETTING VS EFFICIENCY OF TEST FILM GRATING

6.0 PERFORMANCE EVALUATION

The operation of this optical recording system was broken into six parts for the purpose of evaluating the performance.

1. CRT and Power/deflection circuits (INFODEX)
2. Lens and field flattening lens (CIR Ltd.)
3. Film Drive Unit (CIR Ltd.)
4. Film Processing (NAPL/CFPU)
5. Video Signal Processing (DREO/SHOE COVE)
6. Overall Operation of the System (DREO/SHOE COVE)
7. CRT trace parameters
8. CRT Test Result

6.1 CRT and Power/Deflection Circuits

1. The spot size of approximately 0.0007 inch was achieved for the total trace (108 mm) at the CRT. The section of the spot was circular. A 20 MHz video signal was clearly discernable over the whole potion of the trace at the CRT face when viewed with a 25 x microscope.

2. The linearity of the trace was adjusted to give a variation of adjacent 21 dot position of less than 0.0005 inch (12 μm) over 0.386 inch (9.80 mm). The variation of linearity for the total trace with the exception of the outer quarter inch was less than 0.001 inch for 4.25 inch (108 mm) trace. These figures were based on 21 dots equally spaced across the CRT screen.

6.2 Lens and Field Flattening

1. The lens was positioned at the point determined previously at DREO to have the best MTF by observation of 20 MHz signal using a microscope.

2. The manipulation of the tilt of the field lens had little effect on the image plane curvature which was 0.003 inch at the extremities of the trace.

3. With the lens at full aperture (f/2.0), an 18 MHz signal was observed for the central area at the image plane, but it was limited to 17 MHz up to 1 cm from the edges. A position marked as f/2.5 on the lens improved the frequency response at the edge to about 18 MHz and 20 MHz at the centre. This f/number position was fixed. These frequency estimations were observed with 125x microscope looking directly at the image (Capstan removed).

4. The M.T.F. was not measured but at the edges was estimated to be 20% and 90% at the centre for an 18 MHz signal at the image plane with the lens speed at f/2.5.

5. The mechanism for positioning the lens had insufficient rigidity and the micrometers were non-linear in motion. A support screw at the centre of gravity of the lens was added which improved the lens stability and provided image height adjustment.

6. The linearity measurements with the 21 dot pattern (Reduced 1.36:1) at the film plane was identical to the CRT results (6.12) after final electronic adjustments in the linearity of the CRT trace were made.

6.3 Film Drive Unit

This system operated efficiently and as was intended, requiring very little attention regarding maintenance. The film was loaded in a cassette in a darkroom, placed in the uppermost position (Figure 1), threaded accordingly and attached to the spool in the take-up cassette. Refer to Appendix A - the Operators Guide.

6.4 Film Processing

The test film processing was initially done by CFPU using 885 Chemistry at 85° F and 4 ft/min to a gamma of 1.25. When the processing was transferred to NAPL a compromise chemistry was used with lower gamma and contrast. This developer was Versaflo at 90° F, 2 Rack at 4 ft/min subsequently changed to 5 ft/min to lessen the base + fog and gave a gamma of 1.1.

6.5 Video Signal Processing

The establishment of recording signal level from the HDDT was found to be complex. Since May 79 a new A.C. coupled Infodex amplifier for the CRT was installed after meticulous checking of its parameters by DE Technical Support Staff, however, poor interferograms resulted. A further modified AC coupled amplifier of improved performance at higher frequencies was installed. Over-driving the amplifier only obtained poor results. The final amplifier constructed by Remote Sensing Section had a much larger voltage swing resulting in more satisfactory interferograms. Circuit design of these amplifiers is shown in Figures 19, 20, and 21 respectively.

A block diagram in Figure 16 shows the signal strengths and path for recording from the HDDT recorder. Attenuators in the DREO Interface Unit were adjusted to maintain these signal levels. The video signal level received from the SEASAT satellite (via the HDDT) varied from 100 m volts to 300 m volts peak to peak.

6.6 Operation of the Recording System

The system functioned mechanically without fault, however, several electronic problems were encountered and resolved.

1. Line power surges from Newfoundland Light and Power Co. caused CRT high voltage failures, as a result, line surge protection was installed.

2. Upon examination of the HDDT signal with a spectrum analyser, video frequencies greater than 21 MHz were modulating the CRT output. To prevent this, a 22 MHz bandpass filter was installed.

3. The air compressor was prone to accumulating large quantities of water in its pressure tank. It was recommended that it be drained every day prior to use.

6.7 CRT Trace Parameters

The CRT parameters could be adjusted with relative ease with the exception of the GI Bias. To achieve the correct exposure at the film a number of combinations of CRT parameters were tried.

1. The brightness control operated the cathode to ground Bias was normally +35 volts in the off position. A monitor of the brightness level in the form of an milliammeter on the Infodex Power Supply Unit upper panel indicated zero milliamps at +35 volts and 20 mA at near zero volts (zero light emission or cut off). The monitor point in the cathode is a current source transistor located in the CRT enclosure.

2. Constrast Control

   This was a video preamplifier that was bipassed during subsequent video amplifier redesign.

3. Video Level

   The video signal was applied to the GI Bias after amplification by the video amplifier (Section 4.5). The amplitude swing available was to a maximum of 37 volts peak to peak without distortion at 22 MHz.

6.8 CRT Test Results

The basic test of quality of production of interferogram was its correlated image however initial approach was to determine the maximum resolution obtainable and its largest diffraction efficiency. This was illustrated in Section 5.3.2.

7.0 CONCLUSIONS

7.1 The CRT and Power/Deflection Unit

The CRT, operating at high cathode voltages (25 kv) required protection from line surges for better reliability. The light intensity from the CRT was adequate for the recording purposes and exhibited the high resolution and linearity claimed by the contractor (Infodex Ltd., Waterbury, Connecticut).

7.2 The Lens and Flattening Lens

The lens operation was adequate giving an estimated MTF of about 90% over two-thirds of the sweep at 18 MHz and 20% MTF at the edges. Chromatic abberation was present reducing the efficiency. The flatness of the image field was not sufficient and the field flattening lens was considered not to have sufficient effect at the edges therefore contributing to the lack of MTF at the edges of the trace at the film plane (at f/2.5).

7.3 Film Drive Unit

Despite CIR manufacturing problems due to loss of manpower, the film drive unit operated without fault. The quality of the printed circuit boards appeared to be low but functionable.

7.4 Film Processing

Excellent service was obtained from NAPL and CFPU in processing the RAR 2498 film and the quality and handling was professional.

7.5 Video Signal Processing

The recording of interferograms has been plagued with problems. The quality of imagery obtained was low initially. This was blamed on the video amplifiers received from Infodex because it was D.C. coupled.

A remodelling of the video amplifier into A.C. coupled device did not solve the problem completely but improved image quality to survey level. Subsequence rebuilding of the amplifier was successful but resulting imagery remained at survey quality.

7.6 Operation of the System

The system was operated by one contract person from NORDCO with the ability to operate the HDDT recorder without any difficulty.

7.7 Assembly of the Recorder

1. The assembly and alignment of the recorder was difficult and time consuming.
2. Larger sub-assemblies and a design less dependent on levelling equipment is required.
3. The assembly for the lens was unstable and non-linear in mechanical adjustment.
4. A design incorporating real time viewing of the signals to be recorded at the film plane with film installed would have been desirable, or failing that, the ability to observe the CRT trace would have been an asset.

7.8 Imagery

Two basic forms of imagery of the earths surface were required.

a) Survey

This imagery had maximum contrast and 100 x 100 metre resolution.

b) High Resolution

This imagery was also high contrast but with 30 x 30 metre resolution.

The assessment of the quality of interferograms recorded using this optical recording system at Shoe Cove also depends largely on the correlation efficiency. At DREO, a recently installed development optical correlator (designed and constructed by CIR Ltd) was used to evaluate the interferograms. Several thousand kilometres of earth surface imagery has been produced. The quality of imagery achieved with this optical recorder has been classified as survey with 40 x 80 metre resolution being typical.

The CRT parameters for survey quality imagery were:

Video Level → 34 volt peak to peak

GI Bias → -52 volt (D.C.)

Cathode Bias → +16 volt (50 ma or Dial)

8.0 TEST EQUIPMENT

8.1 Test Jig for Mechanical Alignment

The alignment unit comprised of a cast iron jig, clamped to the major support rails of the instrument maintaining constant position and alignment. On the parallel sliding bars, an aluminum block supported a 0.0005 inch resolution dial guage. The gauge was able to traverse 108 mm across the image plane without diverting more than .001 inch.

The jig was used to align two items, the CRT face plate and the capstan film drive with the rails (Figure 7 and 8).

8.2 Traversing Microscope

The microscope was capable of being inserted into the system to observe the CRT trace at the face plate and the image of the trace after the lenses.

Screw adjustments on the base provided accurate horizontal positioning so that when traversing, it could follow the trace. Similar screws for the vertical plane ensured that the microscope remained in focus while traversing, (see Figure 10). A variety of eyepieces and objectives were available to provide a range of magnifications.

The traversing of the microscope was sufficiently accurate as not to deviate more than .0001 inches from its true course.

8.3 Spirit Level

A 25 centimeter long spirit level manufactured by Wyler (Swiss) with graduations of 0.0005 inches was required to align the bars to carry the lens and CRT with their respective tables. (see Figure 3).

8.4 Bull's Eye Pattern

The bull's eye Pattern provided by Infodex to measure the linearity of the trace consisted of 21 crosses each with two concentric circles. The crosses were spaced with an accuracy better than .002 mm across the length of 108 mm at 9.800 mm intervals.

The demagnified version 1.36:1 was manufactured by Shaw Photogrammetric Services Ottawa using a standard step and repeat method over approximately 80 mm with similar positioning accuracy to the Infodex Pattern.

9.0 REFERENCES

1. "The SEASAT A Synthetic Aperture Imaging Radar System", R.L. Jordan and D.L. Rodgers J.P.L. Publication, California Institute of Technology Pasadena, California, U.S.A. May 77.

2. DREO Technical Note 79-14 "Mechanical Engineering Design of DREO Optical Recorder for SEASAT", D. Hidson and V. Pede, September 79.

3. Canadian Instrumentation and Research Ltd., (CIR) Toronto, Canada. Michael Failes Contract #28Q7700061.

4. Infodex Ltd. Waterbury, Connecticut U.S.A.

5. CRC Technical Note 695 "Optical-Recorder Design Considerations for the Canadian SEASAT A Ground Station" E.B. Felstead and G.E. Haslum, Nov. 78.

6. SEASAT Recorder System Film/Developer Evaluation Test & Evaluation Report 8/78. Capt. J. Webster CFPU.

APPENDIX A

OPERATOR GUIDE FOR DREO OPTICAL RECORDER #2

PART 1 - QUICK CHECK LIST

PART 2 - OPERATOR'S GUIDE

APPENDIX A

DREO OPTICAL RECORDER #2

QUICK CHECK LIST

TURN ON SEQUENCE

1. Turn on CRT Power Unit and extra fan (Infodex), allow 15 min. warm-up.
2. Switch on H.V. at the rear of CRT Power Unit.
3. Load film into cassette and then into Film Drive Unit.
4. Close doors on Film Drive Unit.
5. Release light traps on cassettes.
6. Ensure air supply to bearing and table.
7. Switch on Film Drive power (CIR) on Film Drive Control Unit (FDCU).
8. Check alarms and indicators (LED) on FDCU.
9. Increase brightness level to 45 mA. indicated on meter on Infodex P.U.
10. Go to STANDBY AND RUN LEADER on FDCU.
11. Monitor correct LED operation and loop lock on FPCU panel.
12. Start recording imagery after 30 minutes warm-up.
13. Listen for Phosphor protect relay to operate and monitor TP1 and TP3 on Infodex P.U.
14. Switch to RECORD on FDCU.
15. Pauses can be initiated by operating STANDBY (FDCU).
16. STOP button terminates Film Drive at any time during or after HDDT Recorder playback.

TURN OFF SEQUENCE

1. STOP button terminates Film Drive operation on FDCU.
2. Reduce brightness to zero on mA meter.
3. RUN LEADER goes to STANDBY when finished, Depress STOP.
4. Rotate the light traps on the cassettes to close.
5. Open Film Drive Unit door.
6. Cut film at supply cassette, remove film in total darkness from cassette and place film in light tight plastic container.
7. Switch off H.V. on CRT Power Unit.
8. Switch off Power on CRT Power Unit.
9. Switch off extra cooling fan on CRT Power Unit after 30 min. cooling.
10. Shut off air supply.
11. Switch off power to FDCU.

APPENDIX A

OPERATORS GUIDE FOR DREO

RECORDER #2

1. Film Loading and Handling

The concept of this recorder is similar to the DREO Back-Up Recorder.

1. The film cassettes should be loaded in a dark room without safe lights (see Figure A-1).
2. Three feet of leader is sufficient to thread the film.
3. The emulsion side should be uppermost.
4. The cassettes are NOT interchangeable.
5. The cassettes are NOT light tight without the light trap secured.
6. The loading of the film thro' the slot in the cassette can be facilitated by using a piece of folded paper.
7. The film is threaded onto the Film Drive Unit as indicated in Figure A-2.
8. After loading both the doors should be screwed down tightly to prevent light leakage and disable the door alarm systems (see Figure A-3).
9. DO NOT ATTEMPT to rotate the capstan film drive without compressed air to the air bearing.
10. Film tension rollers should be cleaned when dusty.
11. Care should be exercised to disengage light traps before commencing with Section 2. (A common error is 'tension' LED due to light traps re-engaging).

2. Activation of the Film Transport Mechanism (Film in place)

1. Switch on power to Film Drive Control Unit (FDCU) in the blue rack, warm-up 15 minutes. (Figure A-3).
2. Check air supply 50 lb./sq. in. to air bearing. (green LED-normal on Alarm panel).
3. The group of LED's on the FDCU in the blue rack indicates the condition of the film transport system circuits and therefore the Film Drive Unit as indicated in Table A-1.
4. The RUN LEADER button will take all the film that is exposed during loading when the door is open, into the take-up cassette. (1-1/2 feet).
5. RECORD button is used for continuous recording.
6. The phase lock loop usually requires 1-5 seconds to lock in when RUN LEADER or RECORD is activated.
7. When a FAULT is indicated, operate STOP button and repair fault.
8. STANDBY button can be used for parameter changes not involving the film transport equipment.

TABLE A-1

ACTION BUTTON ACTION STATE	STOP INACTIVE (Red)	 ACTIVE (Green)	STANDBY INACTIVE (Red)	 ACTIVE (Green)	RUN LEADER/RECORD INACTIVE (Red)	 ACTIVE (Green)
Circuit Phase Lock Loop	X		X			X
Tension Servo	X			X		X
Start CCT	X		X		X	
Loop Lock Alarm	X		X			X
Film Drive Alarm	X			X		X
Y Deflection	X		X		X	

The above table indicates normal LED operation with sequence: STOP; STANDBY; RUN LEADER/RECORD on the Film Drive Control Unit (CIR Ltd)

3. The Alarm System

This is activated when any of the alarms register and the red LED flashes next to the faulty operation and buzzer sounds. Normally no LED's flash.

4. Air Supply

1. The alarm system for air supply is self explanatory. The air in the table and the bottle are automatically connected to the bearing if the power fails or the pressure fails below 48 p.s.i.

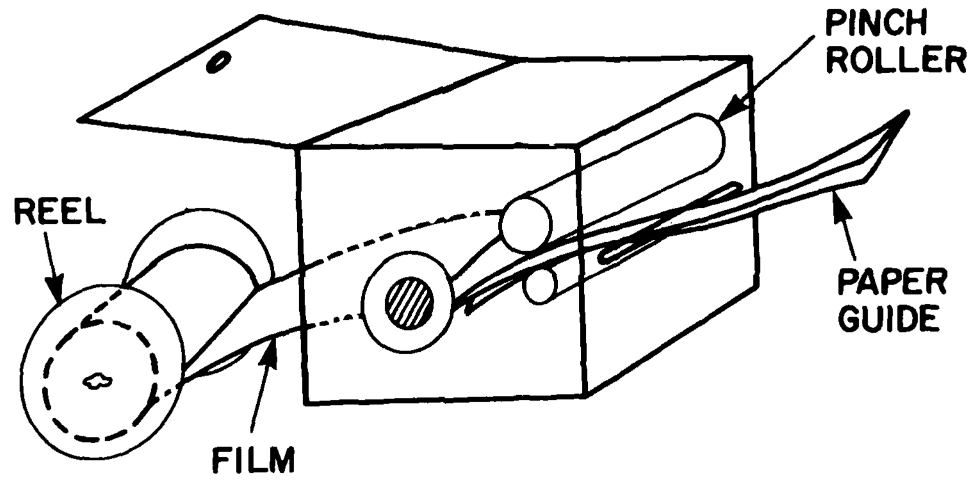


FIGURE A-1. FILM LOADING TECHNIQUE FIGURE

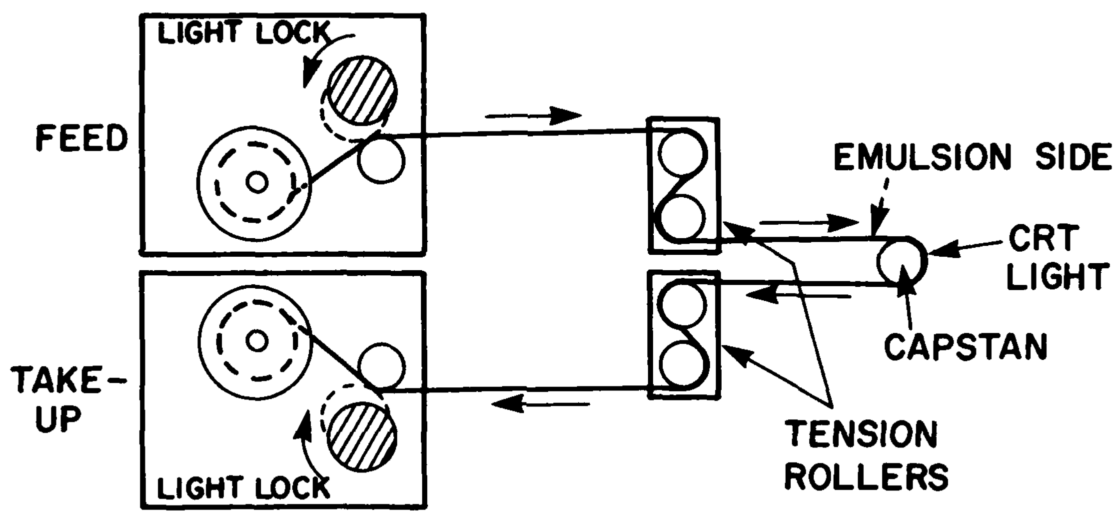


FIGURE A-2. DIAGRAM OF FILM LOCATION IN FILM DRIVE UNIT

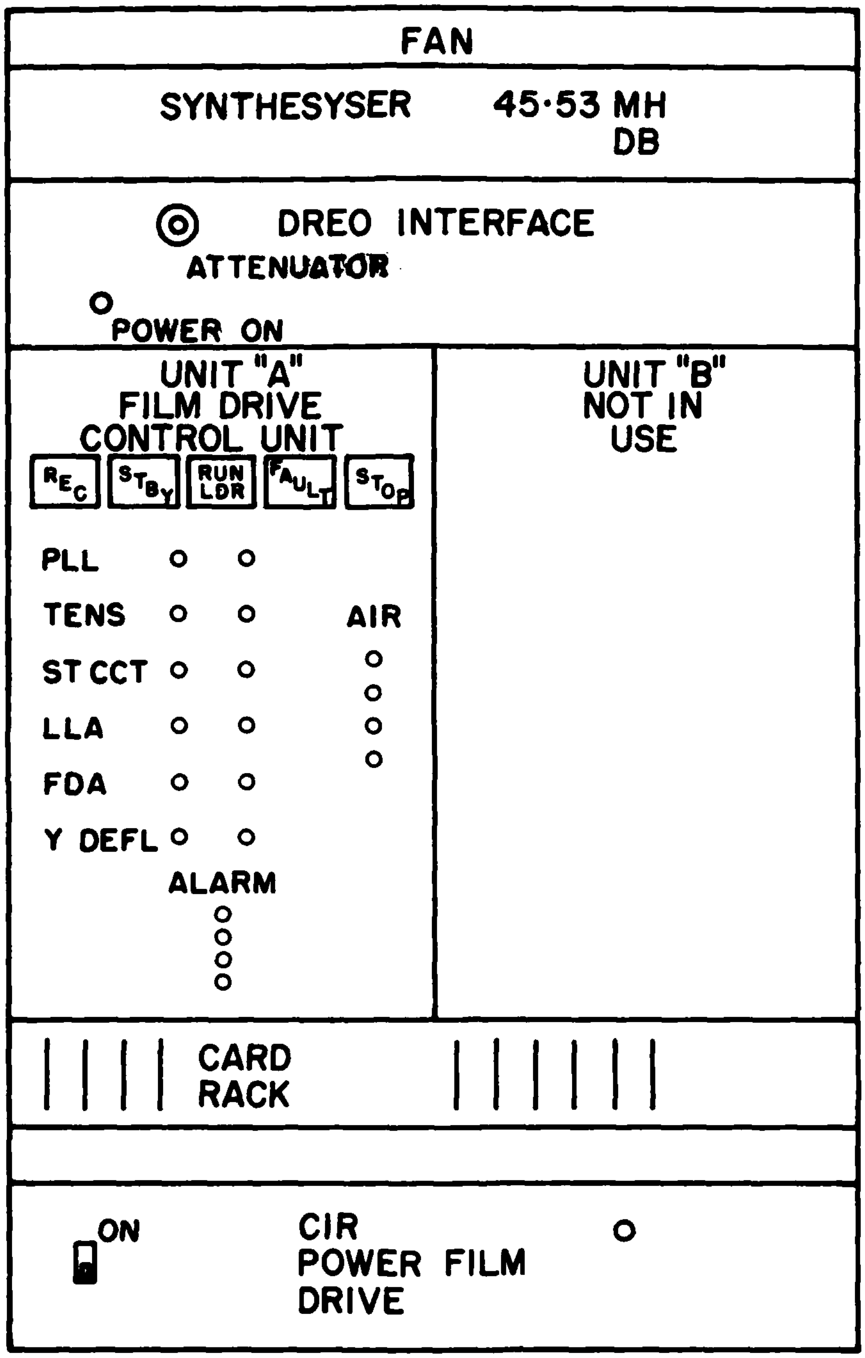


FIGURE A-3. FRONT PANEL OF FILM DRIVE CONTROL UNIT

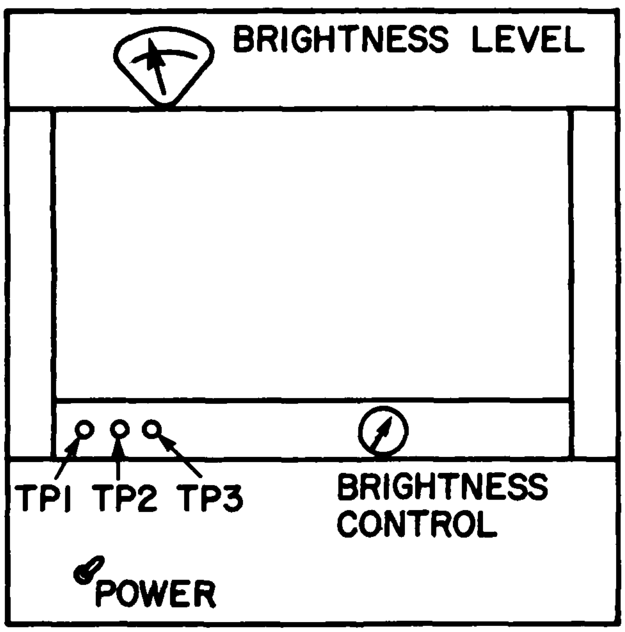


FIGURE A-4. FRONT PANEL CRT POWER SUPPLY

APPENDIX B

TENTATIVE DESIGN PARAMETERS FOR THE DREO OPTICAL RECORDER

APPENDIX B
TENTATIVE DESIGN PARAMETERS FOR THE DREO OPTICAL RECORDER

Revised January 11, 1978

CRT

Spot Size	- 0.0007 inch-center } Infodex 0.001 inch-edge }
Phosphor	- P-11
Beam Current	- < 1 μa
Beam Voltage	- 25 kV Infodex
Number of CRT's	- 2 Infodex CRT
Nominal Screen Size	- 5 inch

Range Recording

Full Aperture Width at CRT	- 4.25 inches (108 mm)
Magnification from CRT to Film	- 1.36:1
Full Aperture at Film	- 3.12 inches = 79.3 mm
Highest Spatial Frequency	
at CRT	- 31.5 lp/mm
at Film	- 42.9 lp/mm
Number of Cycles of Highest Spatial Frequency	- 3398
Beam Velocity	
at CRT	- 6.66×10^5 mm/s
at Film	- 4.90×10^5 mm/s
Time Duration on One CRT	- 161.8 μs
Maximum Spot Position	- 0.04% Desired
Error Over Entire CRT	- 0.05 to 0.1% - Infodex
q at Film	- 306,000

Azimuth Recording

Nominal Film Velocity	- 40.0 mm/s
Film Velocity Range	- 35 to 45 mm/s
Film Velocity Setability and Stability	- $\pm$0.06%
Velocity Controls	- Hand Setable, and Remote Setable from Satellite Velocity Information
PRF	- 1646.760 Hz
p	- 162,000
Spot Size at Film	- 0.65 mil (16.5μm) (equivalent to a >MTF of 50% at 31 lp/mm)
Sample Spacing at 1647 Hz	- 24.3 μm
CRT Capable of Deflection In Azimuth Direction for Correction of High Frequency Film Velocity Instability	

Film

Type	- Kodak RAR 2498
Film Base	- Estar
Thickness	- 4 mil
MTF at 40 lp/mm	- >50%
Film Width	- 5 inch - 1/32 $\pm$ 1/64
Sensitivity	- 0.05 ergs/cm^2 for t_a = 0.5
Length of Film on One Channel for 1 Ten Minute Pass	- 24 m (79 ft.) not including leader
Max. duration of film (CAPSTAN) from desired position	- $\pm$ .0005 inch

Recording Lens

f/number	- f/2.0
MTF at image	- Preferable to be $\geq$50% at 43 lp/mm across entire 79 mm aperture

Aspect Ratio, A_f = q/p, at Film - 1.89

Annotation

Azimuth	- LED's to record GMT on film from data received during pass
Range	- LED to draw continuous line on film during pass

Mechanical

CRT-Lens-Capstan Spacing	- Dependent on lens selected
CRT-Lens-Capstan Spacing Setability	- $\pm$ 0.0005 inch
CRT-Lens-Capstan Spacing Stability	- $\pm$ 0.001 inch
Lens Centering Relative to Axis	- $\pm$ 0.01 range $\pm$ 0.005 azimuth
Tilt of Lens Axis Relative to Optic Axis	- 8.0^o

APPENDIX C

BLOCK DIAGRAMS

TEST GENERATOR BOX

WITH WAVEFORMS

TEST GENERATOR BOX

The test generator supplies the necessary sync pulses (X-GATE, UNBLANK), that allows the Infodex Power Unit to switch on, without using data generated by the HDDT. For calibration purposes, it provides a video signal that produces a 21 dot pattern across the CRT face. This video pattern, when used with the 21 dot pattern mask, allows the sweep linearity and dynamic focus circuitry to be aligned and focussed on the capstan.

On the "EXT" mode, a signal generator, in our case the H.P. Synthesizer 3335A, is used to trigger the circuitry to produce the sync pulses, plus video signals of 5.0, 10.0, 15.0 and 20.0 MHz sine wave. This allows the systems bandwidth to be determined by observation of the CRT and the image at the capstan and with recordings on film.

Figure C-1 shows the internal connections of the Test Generator Box and its outputs.

Figure C-2 indicates the waveforms expected at various points on the Test Generator Box and on test point TP1 on the Infodex Power Unit.

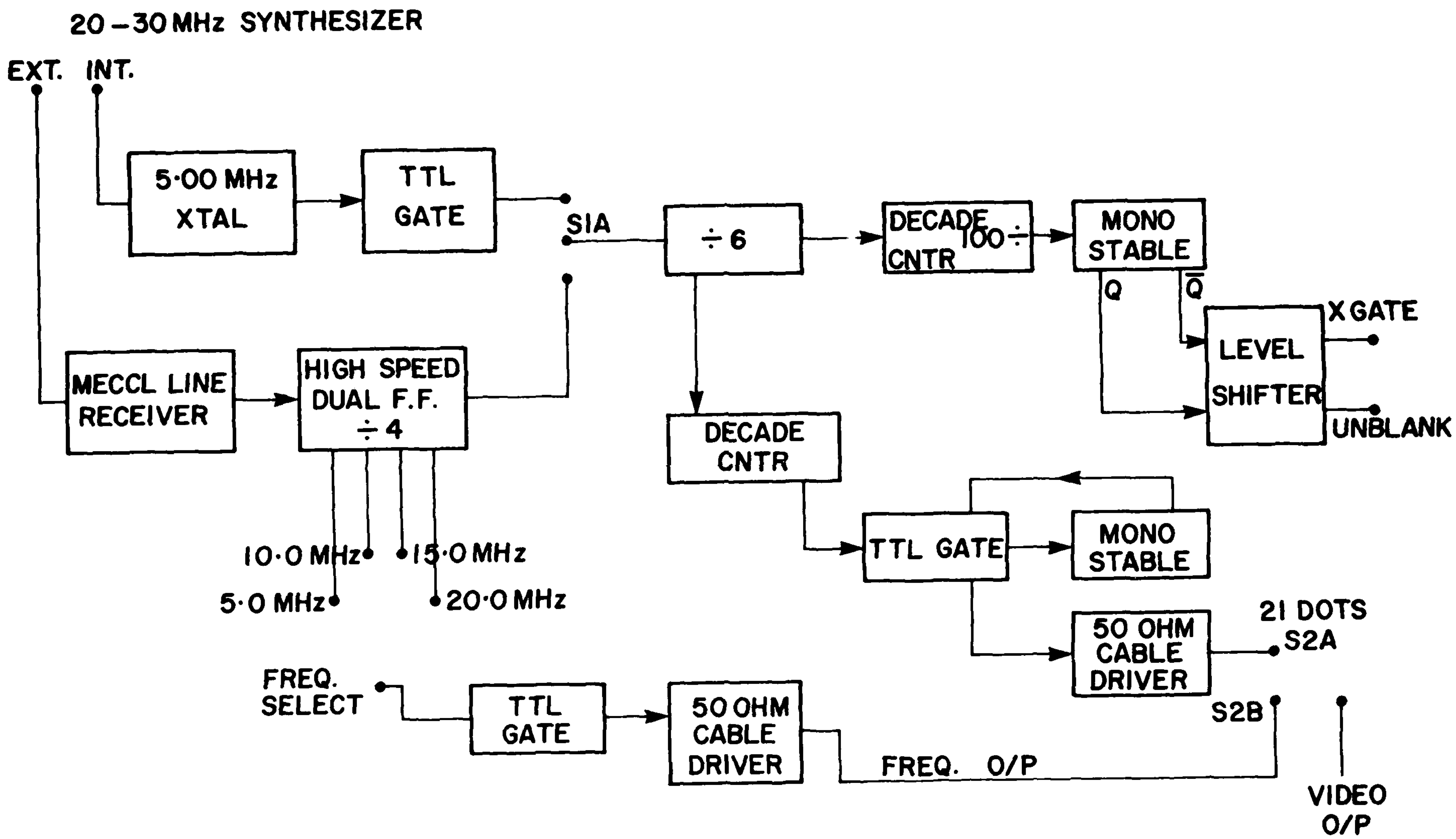
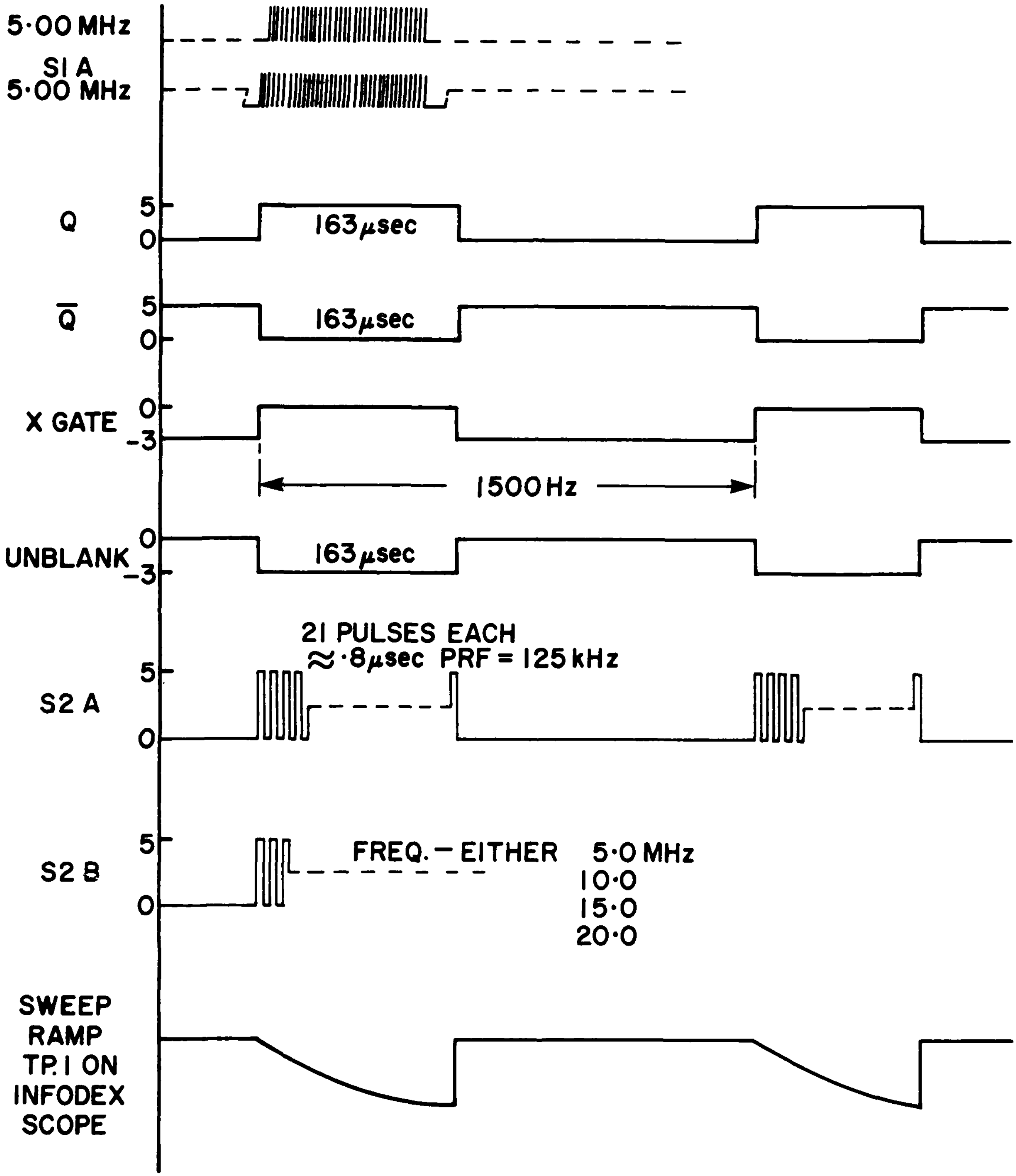


FIGURE C-1
Test Generator Box



Waveforms on the Test Generator Box

FIGURE C-2

APPENDIX D

CRT TRACE ALIGNMENT PROCEDURE FOR INFODEX ELECTRONICS

APPENDIX D

CRT TRACE ALIGNMENT PROCEDURE FOR INFODEX ELECTRONICS

When replacing the CRT or if realignment is deemed necessary to correct for nonlinearities in the lens, the following procedure should be followed with Infodex 'Manual' and 21 DOT Generator Data connected.

1.1 Align the traverable microscope (20 x power) on its base at the center of CRT face (using the microscope in Figure 10, Main Report) and focus on the phosphor surface.

1.2 With main power and H.V. switched off, remove the ± 35 volt power leads (violet and red) from the Deflection Amplifier terminal strips (both X and Y deflection amplifies). These are located in the electronics housing on each side of the cooling fan assembly.

1.3 Remove the circuit board cards from positions in the rack

(a) A10 - Dynamic Focus Amplifier
(b) A3, A4, A5, A6 - X and Y linearity correction boards.

1.4 Place the focus coil reversing switch S1 in defocus (center) position, located on Focus Regulator card A8.

1.5 Jumper the Phosphor Protect card, A7, TP3 to ground (TP1).

1.6 With contrast and brightness controls fully counterclockwise, turn on main power and H.V. switch.

1.7 Mark the geometric center of CRT and slowly rotate the brightness control until a defocused spot is visible through the microscope.

1.8 Adjust R2 and R5 centering potentiometers on card A13, (the Centering Coil Board) until spot falls on CRT center, or as close as possible. Adjust R8 and R11 on same card (A13) until spot is uniformally bright and circular (viewed with microscope).

1.9 Turn brightness control fully counterclockwise, place switch S1 (on card 18) in either up or down position, and slowly increase brightness until focused spot appears (view with microscope).

1.10 Alternately, switch S1 up and down and observe that the spot does not move more than two or three spot diameters. If it does move beyond this tolerance, it implies a misalignment of the CRT focus coil. To correct this problem requires factory, or laboratory servicing using the manufacturers Focus Coil alignment procedures, described in the service manual[1].

1.11 Assuming the focused spot does not move beyond specifications, turn the brightness control fully counterclockwise and the power off. Alignment is satisfactory.

1.12 Return Dynamic Focus Amplifier card to A10 slot and power leads ($\pm$ 35 V) to Deflection Amplifier terminal strips.

2. FOCUS REGULATOR AND FOCUS GENERATOR

Continuing with conditions as described in Section 1.3 and 1.12

2.0 Apply Gate and Unblank pulses to the appropriate connectors. Remove the Ground wire from TP3 card A7 (see 1.5).

2.1 Install 'X ON-Axis' Linearity Correction card to slot A4.

NOTE: Because this system operates in single line scan mode cards A3, A5, A6 are not necessary (i.e. "X" OFF-Axis, "Y" ON-Axis and "Y" OFF-Axis linearity correction cards).

2.2 Turn power and H.V. switches on and allow approximately 5 minutes to warm up.

2.3 Set front panel focus control to mid-range and increase brightness until a horizontal trace appears.

2.4 Adjust R3 (course static focus control, on card A8) until an optimum focus in CRT centre is obtained using the microscope.

2.5 On card A10, adjust R11 to focus the RHS of screen and R12 to focus LHS of screen. Steps 2.4 and 2.5 may be repeated to obtain best overall focus.

3. LINEARITY CORRECTION

3.1 Apply a fixed, say 15 MHz, 1.0 vpp. video signal to video amplifier, or preferably, if available, the 21 dot generator[2] signal. The bulls-eye pattern mask should be installed on CRT face to align with video pattern. The microscope should be aligned with the centre spot and adjusted to traverse all 21 dots without defocussing (See Figure D1). Lower power magnification (10x) should be used to avoid parallax when viewing the Bull's Eye pattern and spots simultaneously.

3.2 Refer to manufacturer schematics diagrams, in the Infodex manual, for the "X" ON-Axis Linearity Correction circuit, card A4, and very carefully make the following adjustments.

3.3 Observing with the microscope at a position 3 to 4 dots to the RHS of the centre of the CRT, adjust R22 (card A4) until these dots fall within the bulls-eye pattern centre. If using a fixed 15 MHz frequency, adjust until spacing of the signal shows best linearity when observed through the microscope.

3.4 Translate the microscope towards RHS of the CRT and observe three or four more dot positions and adjust R25 to obtain best results.

3.5 Repeat step 3.4, adjusting R28, 31 and 34 for each breakpoint until RHS is completely adjusted for linearity.

3.6 Repeat steps 3.3 to 3.5 for LHS starting at the centre, adjusting pots R23, 26, 29 32 and 35 respectively.

3.7 Steps 3.3 to 3.6 may have to be repeated because of the interaction between RHR and LHS pots.

These procedures were also used to align the CRT image at the capstan for optimum frequency response of the system and to offset any non-linearities contributed by the relay lenses.

References

1. Infodex Manual

2. 21 Dot Generator Box Appendix C

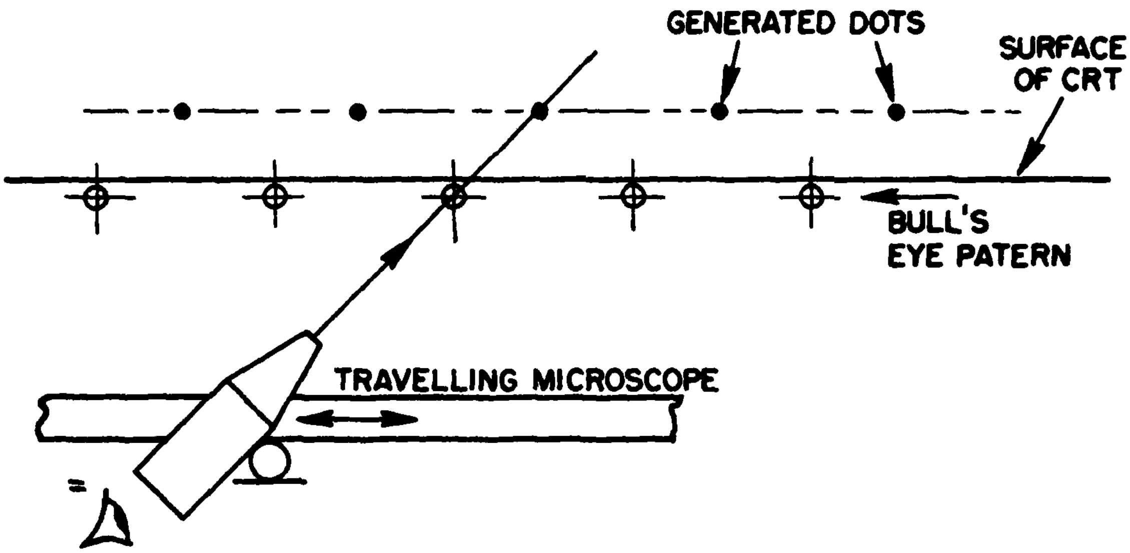


FIGURE D-1 - LINEARITY CHECK AT CRT FACEPLATE

APPENDIX E

CRT FOCUS TECHNIQUES AND PARAMETERS

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CRT FOCUS TECHNIQUES AND PARAMETERS

Determination of CRT Focus and CRT electronic parameters levels are achieved by examination and testing of film exposures using the Test Generator Box (Appendix C).

After completing the alignment described in Appendix D test film was, generated to determine level settings in the following order.

1. CRT Focus

1.1 Set Lens - f/2.8
Cathode Bias - 50 MA
Video Level - 150 mvolts
Video Frequency - 5 MHz
G1 Bias - -52 volts

1.2 Initial mechanical setting should have been determined in Section 3.4 during alignment.

1.3 Variation of CRT Focus only over a range of ± 0.25 mm in 0.05 mm steps recording each exposure.

1.4 Process Film with D19 Developer for four minutes
with Stop Bath for 30 seconds
with Rapid Fixer for 2 minutes.

1.5 Examination of the film for best focus using

1. Visual - eyepiece and if good
2. Fourier Transform technique (see Section 3.0 Appendix E) to determine the proximity to best focus.

1.6 If a best focus was not achieved then repeat the above process in the appropriate area of improved focus.

1.7 When near best focus was achieved the Video frequency increased in 2MHz steps to 18 MHz and repeat operation in at best focus.

1.8 If video frequency is lost before 18 MHz then best focus was not achieved. Repeat operation 1.3 at highest visible frequency attained.

1.9 The balance of the frequency content in Range should also be noted to determine how tilt in focus at the image plane.

Compensation for the image tilt due to the lens alignment defocus can be best accomplished in the following manner.

1.10 Image Defocus in Range

With best CRT focus obtained in any part of the sweep, two micrometer adjustments were effective to balance the frequency response.

1. Lens Base LR1
2. CRT Base CR1

This should be done carefully and changes noted as a return to the original state is always a possibility. There is also a possibility of CRT defocussing with this action. Hence a return to section 1.3 for CRT Focus check.

2. CRT Electronic Parameters

The parameters settings in section 1.1 may be varied in order to achieve improved interferograms recordings. However, much experimentation showed that high video levels at the CRT were the most effective improvement and small changes of G1 Bias and Cathode Bias were not nearly as effective.

The values of parameter listed in Section 7.10 were the result of extensive evaluation of correlated imagery produced by DREO optical correlator.

3. Fourier Transform Techniques

In order to establish the quality of the test recording made with the Test Generator Box, the efficiency of the grating produced was measured by its ability to diffract light.

A one inch diameter area of a test film was exposed to an expanded parallel beam HeNe Laser source and focussed to its fourier transform using a simple 150mm focal length convex lens. The spatial displacement of the light due to the diffraction by the grating was measured by recording the intensity of that point (see Figure F-1).

The efficiency of the test film was established by the ratio of diffracted intensity to D.C. or non diffracted light. The higher the efficiency the better is the test film grating.

An example of a Fourier Transform is shown in Figure 22 of main report.

The theory of this optical phenomena is adequately covered in many optical text literature including 'Introduction to Fourier Optics' by J.W. Goodman.

4. Interface Unit

1. This unit is used to trigger and sweep the optical recorder for the incoming imagery from the HDDT.

2. A variable attenuator on the face of the equipment adjusts the level of the video signal which subsequently delivered to the CRT.

5. Infodex CRT and Power Unit

This unit has 25 kv. power supply and care should be taken not to mishandle H.V. cables and connectors.

1. The power unit is switched on and the monitoring points TP1, TP2, and TP3 (see Figure A-4) monitor the sweep and pulse circuits (via the Interface Unit) needed generate the CRT display (The HDDT or a simulator must be connected) and the Phosphor Protect Relay should be heard to operate. Warm-up time of 15 minutes or more is required.
   TP1 - Sweep ramp 162.8 sec.
   TP2 - Y Deflection - not used
   TP3 - Unblank Pulse +35 v, negative going, 1600 hz.

2. When these testing points are considered satisfactory, (see also Figure A-4 the high voltage switch may be operated at the rear of the equipment.

3. The current meter at the top front of the rack is an indicator of relative change in the operational beam current (or Cathode Bias equivalent) and should be kept around 45 mA. This is controlled by the brightness knob on the front.

4. The contrast control chould largely be left alone as it will be present using it in conjunction with the Interface altenuator to give a video output of ≈ 2.0 volts with 50Ω termination.

5. All the other controls are related to trace position or focusing and SHOULD NOT BE MOVED.

6. The CRT has been carefully aligned and should remain so if not touched.

6. The Lens

The lens was designed especially for this system and has been aligned to give optimum results. The MICROMETERS should not be touched. It is a spring loaded suspension system that can be upset with mechanical over-loading.

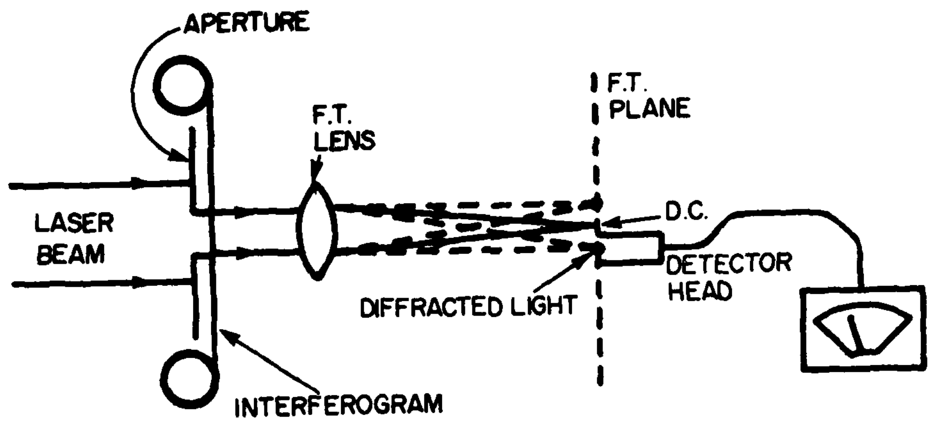

FIGURE E-1 - FOURIER TRANSFORM FREQUENCY INTENSITY MEASUREMENT

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13. ABSTRACT

This report details the installation and operation of a precision Optical Signal Recording System for Synthetic Aperture Radar transmissions from SEASAT-A Satellite. The system was for the most part constructed under two contracts with Canadian and U.S. industries.

Uncorrelated imagery stored on high density, digital and analog tapes was transposed onto film as interferrograms for optical correlation at DREO.

The resulting imagery was acceptable as survey quality for archiving by NAPL.

The Remote Sensing Section of DREO coordinated the installation and testing of the Recorder at the Shoe Cove Satellite Receiving Station, Newfoundland. In March 1980 the recorder was removed from Shoe Cove for installation at DREO Ottawa.

UNCLASSIFIED
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KEY WORDS

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INTERFEROGRAMS
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CRT

HDDT RECORDINGS

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